Working and Finishing Properties of Five Wood Species Grown in Bangladesh

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Abstract

Wood working properties is very important in order to select wood for particular use. The study was conducted to assess the working properties of five wood (main stem portion) species- lambu, arjun, jhau, palmyra palm and acacia hybrid. The working properties were carried out in two different methods, namely : machining and handtools. The effects of machining properties, such as- sawing, planing, shaping, boring, mortising and turning were tested on these five wood species along with handtools test. The sawing qualities of these wood were determined by manual feeding of logs to the saw blade. The evaluation of each operation was based on frequency of occurrence of defect free samples. Finishing properties were evaluated with the application of two different types of polishing materials, viz.: shellac and carpa as well. Each sample was visually observed and classified based on five quality grades. The results indicated that acacia hybrid had an excellent working performance in all properties. All rated excellent shaping result in handtools operation except palmyra palm. Palmyra palm yielded very poor results in shaping, boring, mortising and turning tests.

সারসংক্ষেপ

কাঠের সুষ্ঠু ব্যবহারের জন্য সঠিক কাঠ নির্বাচনে কাঠের গুণাগুণ সম্পর্কে ধারণা থাকা অত্যাবশ্যক। অত্র গবেষণার আওতায় পাঁচ প্রজাতির কাঠ - লম্বু, অর্জুন, ঝাউ, তাল ও একাশিয়া হাইব্রিড এর কান্ডের প্রধান অংশ থেকে সংগৃহীত কাঠের ওয়ার্কিং গুণাগুণ নিরূপণ করা হয়েছে। ওয়ার্কিং গুণাগুণ দুই পদ্ধতিতে করা হয়েছে, যথা - মেশিনিং ও হ্যান্ডটুল্‌স। উক্ত পাঁচ প্রজাতির কাঠের হ্যান্ডটুল্‌স পরীক্ষাসহ মেশিনিং গুণাগুণ, যেমন- স'ইং, প্লানিং, শেপিং, বোরিং, মরটাইজিং এবং টার্নিং প্রভাব পর্যবেক্ষণ করা হয়েছে। স'ব্লেডে হস্ত দ্বারা গুড়ি সরবরাহের মাধ্যমে এসব কাঠের স'ইং গুণাগুণ নিরূপণ করা হয়েছে। প্রতিটি অপারেশনে প্রাপ্ত ত্রুটিমুক্ত নমুনার উপর ভিত্তি করে মূল্যায়ন করা হয়েছে। দুই ধরণের পলিশিং, যথা: শেলাক ও কারপা দ্বারা ফিনিশিং গুণাগুণও মূল্যায়ন করা হয়েছে। প্রতিটি নমুনা খালি চোখে নিরীক্ষণ করার মাধ্যমে পাঁচটি কোয়ালিটি গ্রেডে ভাগ করা হয়েছে। পরীক্ষার ফলাফলে দেখা গিয়েছে যে, একাশিয়া হাইব্রিড কাঠের সকল প্রকার গুণাগুণ অত্যুত্তম। হ্যান্ডটুল্‌স অপারেশনে তাল প্রজাতি ছাড়া সব কাঠের শেপিং ফলাফলও অত্যুত্তম পাওয়া গিয়েছে। তাল কাঠ শেপিং, বোরিং, মরটাইজিং এবং টার্নিং পরীক্ষণে সর্বনিম্ন মানের ফলাফল নির্দেশ করেছে।

Keywords: Wood working; Machining; Handtools; Shellac; Carpa

Introduction

Lambu (*Khaya anthotica*) is an evergreen tree species which has smooth, grey to brown bark, and native to tropical Africa. The trunk of this tree is very straight and reaches considerable heights before branching to form the crown. This tree species become big, 30 to 35 m tall. Now-a-days this tree is available in the northern and western part of Bangladesh. Jhau (*Casuarina equisetifolia*), an evergreen exotic species, attains height 15 to 25 m generally. It comes from Myanmar and Vietnam throughout Malaysia. Jhau is being planted by Bangladesh Forest Department in coastal belt. Arjun (*Terminalia arjuna*) is about 20–25 m tall; usually has a buttressed trunk, and forms a wide canopy at the crown, from which branches drop downwards. The arjun is usually found growing on river banks or near dry river beds in Bangladesh. Palmyra palm (*Borassus flabellifer*) has very large growth pattern and clean habits that make it an attractive ornamental tree, cultivated for planting in homestead, roadside, garden and park as landscape species. This tree is native to the Indian subcontinent and Southeast Asia.

Acacia hybrid (*Acacia mangium* × *A. auriculiformis*), a high yielding variety exotic species, has been introduced in Bangladesh from Northern Australia, Papua New Guinea and Indonesia. It has become very popular to the farmer in our country due to its straight bole and fast growing nature. Variation of machining properties of different wood is influenced by their density, fibre-structure, chemical and mineral contents and many other characteristics. As machining is involved in all common wood working operations, knowledge of the machine ability of different wood is helpful in selection of a particular species for a particular use. The importance of this information lies in marketing of new and inexpensive species and in their conversion for many important wood products (Qasem *et al.* 1981). Wood has traditionally been the basic raw material for the furniture and joinery industries. One of the most important advantages of wood is its easy machine ability in contrast to metal and plastic products. However, its non-uniform characteristics within and between species plays a significant role on its efficient and effective machining. Any surface defects due to an improper machining process will also reduce the quality of the final product, resulting in an increase in the cost of the manufactured unit. Therefore, it is important to evaluate machining parameters and relate them to raw material characteristics (Sofuogluand Kurtoglu 2014).

A very few species are being used in construction, furniture, fixture, door, window and cabinet along with interior works now-a-days. With the rapid expansion of development activities and increase in population, conventionally popular species soon become scarce, resulting abnormal rise in price which forced the users to look for alternate species. Five species, namely: lambu, arjun, jhau, palmyra palm and acacia hybrid, are being used for this purpose as the working and finishing properties are not known to the users. Due to ignorance of working properties of these species, they are either abandoned at the remote site or used as fuel wood. Since the supply of major commercial species of wood has decreased to a great extent, it is imperative to introduce these species into commercial use. The study was thus carried out to ascertain the characteristics of those five wood species in respect of different machining, handtools and finishing tests.

Materials and methods:

In this experiment, five wood species (Table 1), namely- lambu, arjun, jhau, palmyra palm and acacia hybrid, were procured in the log form from Jessore (lambu and arjun), Cox's Bazar (jhau) and Chittagong (palmyra palm and acacia hybrid) and converted to 25.6 mm thick plank by plane sawing. Three grades of sawing, namely- difficult, medium and easy were recorded on the variation of density, grain orientation and the load applied to the saw blade. These planks were seasoned to less than 15 percent moisture content. The seasoned planks were dressed to 19 mm thickness and twenty samples of 19 mm x 125 mm x 1219 mm were made out of each species. All the test samples were sound and free from all defects including stain, knots, surface checks, end splits and incipient decay. Before conducting the tests, these samples were again converted to smaller pieces suitable for different tests as illustrated in Figure 1.

Table 1. Moisture content, age and density of five wood species.

Wood species (Scientific name)	Moisture content (%)	Age (Year)	Specific gravity
Lambu (*K. anthotica*)	12	20	0.54[1]
Jhau (*C. equisetifolia*)	13	15	0.80[2]
Arjun (*T. arjuna*)	14	27	0.52[1]
Palmyra palm (*B. flabellifer*)	14	40	0.56[1]
Acacia hybrid (*A. mangium* × *A. auriculiformis*)	14	22	0.58[3]

Data source

1. Seasoning and Timber Physics Division, BFRI, CTG
2. Chowdhury and Rashid 2007
3. U. K. Rokeya et al. 2010

Ten samples were tested with machines and ten samples with handtools, but twenty samples were tested for the purpose of planing and finishing tests. After the completion of machining tests, the samples were visually examined for sorting out the defect free ones immediately. The occurrence of defects, namely- fuzzy grain, torn grain, raised grain, chipped grain, broken corner, tear out and roughness was recorded. The percentages of defect-free samples based on total samples were determined and these percentages were considered to be the measure of their machining qualities. And then, each sample was visually examined and classified based on five quality grades which are excellent or defect free (no defect) = 1, good (few slight defect) = 2, fair (lots of slight defects) = 3, poor (serious defects) = 4 and very poor (very serious defects) = 5. The performance criteria used for the tests are presented in Table 2.

Table 2. Sample size and qualified grade for each property test used in determining overall performance.

Test name	Dimension (mm)	Performance Criteria	Qualified Grade
Planing	19 x 102 x 914	Excellent and good	1 and 2
Shaping	19 x 76 x 305	Excellent and good	1 and 2
Mortising	19 x 76 x 305	Excellent, good and fair	1,2 and 3
Boring	19 x 76 x 305	Excellent and good	1 and 2
Turning	19 x 19 x 152	Excellent and good	1 and 2
Finishing	19 x 102 x 914	Excellent	1

All the machining tests were carried out according to American Society for Testing and Materials standard test method - "Conducting Machining Tests of Wood and Wood-Based Products" (ASTM D 1666-64 Standard International, 2004). Similar tests were carried out using carpenter handtools. Two types of polish, namely: shellac and carpa, were applied and performance was recorded on the basis of surface finish and smoothness.Gum copal finish is locally known as 'carpa' or 'chandra' polish. The polish is prepared by dissolving gum copal in denatured alcohol. The method of applications the same as that of shellac polish used in finishing cabinets (Qasem et al. 1981).

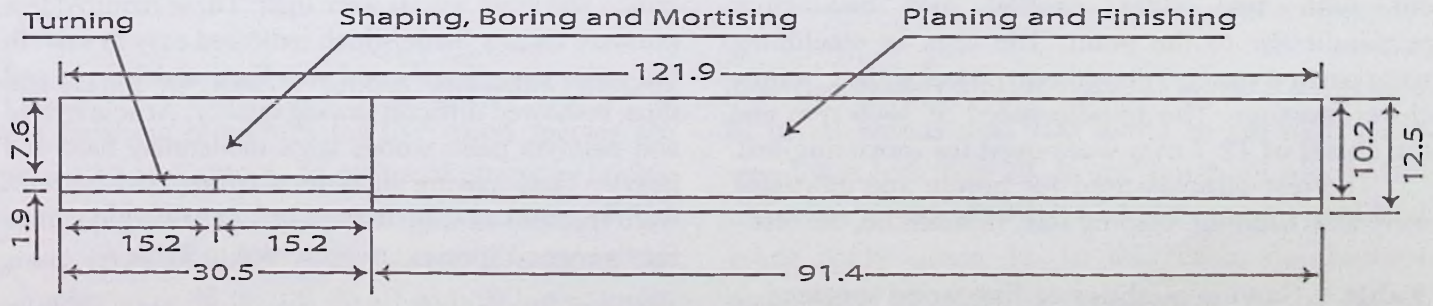

Figure 1. Dimensions of the samples in cm for different tests.

The planing test was carried out in a single surface planer with four cutter knives. The machine was equipped with a variable feed rate that was adjusted. The knives were freshly sharpened for each species and each test. Machining parameters are listed for planing tests in Table 3. The same number of samples were tested with the carpenter's hand planner and similar procedure of testing was applied. The planing test samples were used for the finishing test after completing all planing tests.

Table 3. Machining parameter for the planing tests of five wood species.

Machining parameter	Quantity of parameter	Unit of parameter
Cutter head speed	3000	rpm
Feed rate	636	mm/min
Cutter number	4	nos.
Knife marks	40	nos./2.54 cm
Cutting depth	1.59	mm
Cutting angle	25	degree
Sharpness angle	30	degree

The boring tests were carried out in a 508 mm single spindle hand feed drill press. Two thorough holes were bored on each sample. A one-inch single twist solid center bred point type of wood boring bit was used for the test. The drill was adjusted to maintain a spindle speed of 2850 rpm. In handtools test, boring was done by a carpenter's hand drill (ratchet brace). A one-inch single twist solid centre screwed point type wood boring auger bit was used for the test. Solid hardboard was used as backing underneath in order to avoid the tearing and splintering of samples at the bottom during boring both for machining and handtools test.

The samples used for boring test by machine and handtools were also used for carried out the mortising test by machine and handtools respectively. Two thorough mortises were cut on each sample extending through into a hard board backing. Each mortise was cut with two sides parallel and two sides perpendicular to the grain. The tests in machining were carried out in a foot feed vertical square hollow chisel mortiser. The spindle speed of 3600 rpm and the chisel of 12.7 mm were used for mortising test.

The test samples used for boring and mortising were also used for shaping test. In machine, the test was carried out in a special jig to shape the sample to a curved pattern. A hand feed single spindle shaper with two high speed steel knives having a spindle speed of 6500 rpm was used. The cutter used to obtain a quarter round pattern had a radius of curvature of 12.70 mm. In hand tools test, ripping of the sample was done by carpenter handsaw to obtain the quarter round pattern. The shaping was carried out by carpenter chisel of half-round type.

The turning test was carried out in a variable speed wood lathe at 2400 rpm. A single high speed steel cutter was used to give head and cove for having different turning features as well as the ability to cut at different angles with the grain.

Results

According to the variation of density, grain orientation and the load applied to the saw blade, lambu and arjun woods were light. These required less pressure on saw blade which indicated easy to saw. In the same case, jhau wood was hard and heavy; and thus, it showed difficult sawing quality. Acacia hybrid and palmyra palm woods were moderately hard and heavy. Thus sawing qualities of these two species were medium as well. The results of sawing qualities for five wood species are presented in Table 4.

Table 4. Sawing qualities of five wood species.

Species (Wood)	Type of wood	Sawing quality
Lambu	Light	Easy
Jhau	Hard and heavy	Difficult
Arjun	Light	Easy
Palmyra palm	Moderately hard and heavy	Medium
Acacia hybrid	Moderately hard and heavyMedium	

Table 5 provides the planing results of both machining and handtools tests for five wood species. The qualified grade of planing operations was considered sum of grade 1 and grade 2 in each species. All of the five species showed 80 or more than 80% qualified grade qualities in machining and hand tools tests. In planing operations carried out in general, the highest qualified grade was 100% in each of lambu (hand tools properties), arjun (machining and handtools properties), jhau (machining and handtools properties) and acacia hybrid (machining and handtools properties), and the lowest was only 80 percent (handtools property) in palmyra palm. Lambu scored 95% in machining, whereas palmyra palm scored 90% qualified grade in handtools property.

Table 5. Performance of planing tests for five wood species.

Species	Property type	Nos. of species	Grade of planing property (%)					
			Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Qualified grade
Lambu	Machining	20	60	35	5	0	0	95
	Handtools	20	80	20	0	0	0	100
Jhau	Machining	20	90	10	0	0	0	100
	Handtools	20	80	20	0	0	0	100
Arjun	Machining	20	80	20	0	0	0	100
	Handtools	20	90	10	0	0	0	100
Palmyra palm	Machining	20	30	50	20	0	0	80
	Handtools	20	60	30	0	10	0	90
Acacia hybrid	Machining	20	90	10	0	0	0	100
	Handtools	20	80	20	0	0	0	100

The results of shaping, boring, mortising, turning and finishing properties for five wood species are presented in Table 6. In terms of shaping, boring and turning properties, the percentages of qualified grade (sum of grade 1 and grade 2) among the samples were 80 to 100 in all woods, but palmyra palm had 20 to 60. For mortising property in machining and hand tools tests, the percentage of qualified grade (sum of grade 1, grade 2 and grade 3) in all woods was 100 while in palmyra palm wood was less than 70. In the finishing properties, there was no samples that had 100 percent qualified grade (only grade 1). In this case, the highest percentage of qualified grade was 90 in acacia hybrid, and the lowest was 0 (zero) in palmyra palm species.

Table 6. Performance of shaping, boring, mortising, turning and finishing properties for five wood species.

Species	Property Name	Type	Grade of different properties (%)					
			Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Qualified grade
Lambu	Shaping	Machining	30	50	20	0	0	80
		Handtools	90	10	0	0	0	100
	Boring	Machining	90	10	0	0	0	100
		Handtools	70	30	0	0	0	100
	Mortising	Machining	40	40	20	0	0	100
		Handtools	90	10	0	0	0	100
	Turning	Machining	70	30	0	0	0	100
	Finishing	-	45	30	25	0	0	45
Jhau	Shaping	Machining	90	10	0	0	0	100
		Handtools	100	0	0	0	0	100
	Boring	Machining	80	20	0	0	0	100
		Handtools	50	50	0	0	0	100
	Mortising	Machining	60	30	10	0	0	100
		Handtools	100	0	0	0	0	100
	Turning	Machining	100	0	0	0	0	100
	Finishing	-	80	20	0	0	0	80
Arjun	Shaping	Machining	60	40	0	0	0	100
		Handtools	80	20	0	0	0	100
	Boring	Machining	100	0	0	0	0	100
		Handtools	100	0	0	0	0	100
	Mortising	Machining	100	0	0	0	0	100
		Handtools	80	20	0	0	0	100
	Turning	Machining	100	0	0	0	0	100
	Finishing	-	50	40	10	0	0	50
Palmyra palm	Shaping	Machining	0	20	40	20	20	20
		Handtools	0	60	40	0	0	60
	Boring	Machining	10	10	10	50	20	20
		Handtools	10	20	20	40	10	30
	Mortising	Machining	0	20	20	50	10	40
		Handtools	0	30	30	40	0	60
	Turning	Machining	0	40	40	20	0	40
	Finishing	-	0	0	0	80	20	0
Acacia hybrid	Shaping	Machining	80	10	10	0	0	90
		Handtools	100	0	0	0	0	100
	Boring	Machining	90	10	0	0	0	100
		Handtools	90	10	0	0	0	100
	Mortising	Machining	90	10	0	0	0	100
		Handtools	90	10	0	0	0	100
	Turning	Machining	100	0	0	0	0	100
	Finishing	-	90	10	0	0	0	90

Comparisons of the defect free samples for different tests are shown in Figure 2. In terms of machining test, out of five wood species, jhau, arjun and acacia hybrid showed excellent planing qualities. On the other hand, lambu and palmyra palm showed good and poor planing quality respectively. In handtools test, lambu, jhau and acacia hybrid showed excellent planing qualities, but palmyra palm rated good quality. The most common defects of planing tests were fuzzy grains which were found almost in all the species, the highest being in palmyra palm and the lowest in acacia hybrid. Raised grain occurred in lambu, arjun and palmyra palm which could be removed by simple sanding. This defect was altogether absent in the remaining two species. Knife marks which are unavoidable but never considered as defect were present in all the species. Chip marks were totally absent in all except palmyra palm wood species.

In the boring operation, excellent machining quality was found in all but palmyra palm species, and very poor was seen in it. Arjun and acacia hybrid showed excellent whereas lambu, jhau and palmyra palm rated good, fair and very poor handtools quality respectively.

For the mortising test, arjun and acacia hybrid indicated excellent quality in machining and handtools properties. Lambu and jhau showed fair and good machining quality respectively, and both of these species had excellent handtools quality. In machining and handtools properties, the mortising quality of palmyra palm was found very poor.

In boring and mortising tests, defects typically observed for lambu, acacia hybrid and palmyra palm species were torn grain, and to a lesser extent, fuzzy grain, which generally occurred on the transverse side of the hole. Severely torn and crushed grains were present on the transverse face both boring and mortising in palmyra palm. The quality of the surface was better than the transverse face for all species.

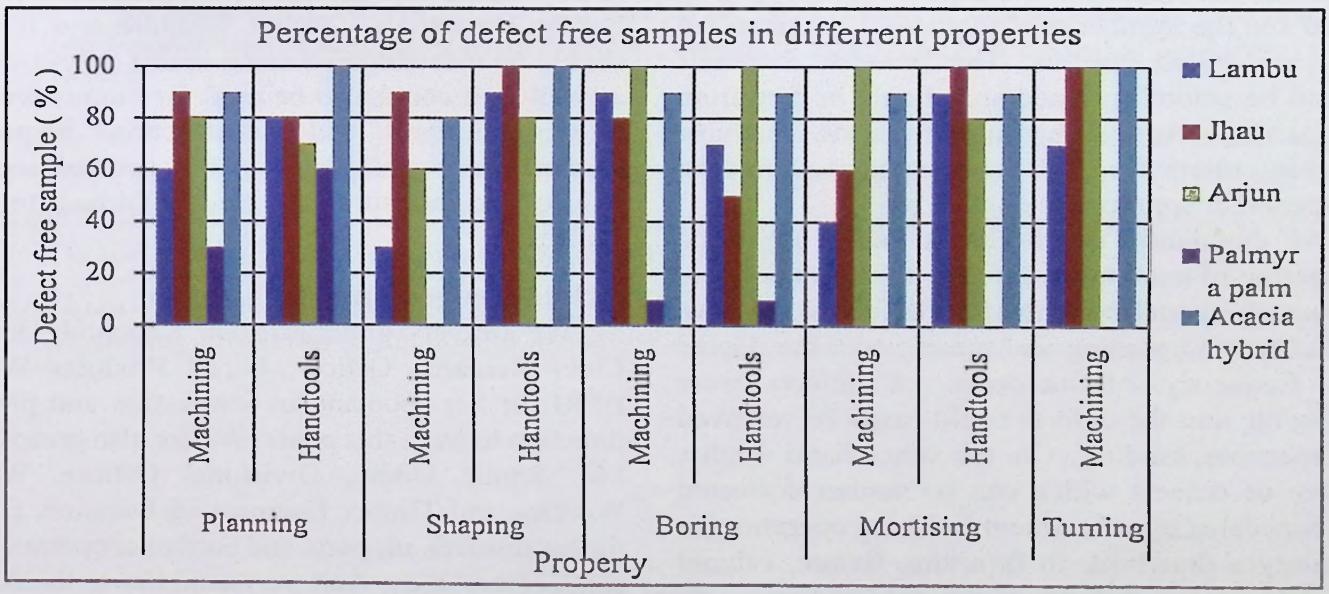

Figure 2. Defect free samples for five wood species in different tests.

In the shaping tests, both jhau and acacia hybrid showed excellent whereas arjun, lambu and palmyra palm indicated good, poor and very poor machining quality respectively. All species except palmyra palm showed excellent, but it rated very poor quality in handtools test. The most common raised grain was the principal defect on end grain of the samples where the knife cut against the grain. The major defects were raised, torn and chipped grains which were seen in palmyra palm.

In terms of turning test, excellent qualities were indicated in jhau, arjun and acacia hybrid wood species. Lambu showed good whereas palmyra palm rated very poor turning quality. Raised grain was present, generally occurring on the curved edge of all samples where the knife cut against the grain in all the five species but predominant only in palmyra palm. Broken corner, raised and torn grains were insignificant in all species except palmyra palm.

Discussion

The defects may be caused by feed speed, which plays an important role in wood processing. High feed speed can cause a poor surface, especially for hardwood. The feed speed of planing test should be slow, but capacity should also be considered. For good machining quality, the cutters used in the machine should be maintained properly. Generally, deep cuts should not be made. The number of blade traces in unit distance should be high. The combination of the most suitable feeding speed and the number of blades should be provided for each wood species. The wooden materials should be smooth-grained and should be free from deformations that cause grain deviations. The most suitable cutters for each wood species should be sharpened at appropriate angles.

As evaluation of results is based on visual inspection of machining defects, it was not possible to quantify them. In many of the defective samples, particularly in planing and turning test, the degree and frequency of incidence of defects were negligible and the defects could easily be removed by adequate sanding. On the other hand, higher degree of defects which can be neither corrected nor concealed by subsequent finishing operations is certainly a drawback in furniture, fixture, cabinet and interior wood work where appearance counts most.

Due to the limitations of the available equipments and machines, extensive investigation of the machining properties with the introduction of different variables like feed rate, thickness of cut, cutting angle etc. could not be carried out. These are necessary for modification and improvement of machining operations for optimum results.

Conclusion

The study was carried out to ascertain the behaviour of these species to different important machining and hand tools properties in fairly typical commercial conditions generating some valuable information on the suitability of different uses. The present results, however, are indicative values and may be used when and where a particular property or a group of properties are to require in the selection of those species for specific uses. Working and finishing properties indicate that all wood species should have potential suitability in different purposes. Palmyra palm wood may be used for construction and inferior furniture materials. Arjun wood may be suitable for medium grade furniture and fixture. Jhau wood could be suitable for quality furniture, fixture and turnery works along with construction materials. Lambu wood should be acceptable for medium grade furniture materials. Quality furniture and fixture should be manufactured using acacia hybrid wood as well as it could also be used for turnery works, interior designs and construction purposes. Commercially using these five species should reduce the pressure on the traditional timber species.

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