EXPLORATORY TESTS ON MACHINING AND RELATED PROPERTIES OF FIFTEEN TROPICAL AMERICAN HARDWOODS

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EXPLORATORY TESTS ON MACHINING AND RELATED PROPERTIES OF FIFTEEN TROPICAL AMERICAN HARDWOODS

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Introduction

The Forest Products Laboratory is increasingly receiving requests from American importers and manufacturers for information on tropical American hardwoods. The objectives of the work here reported were to obtain information on the machining and related properties of fifteen of these woods for comparison with native hardwoods and to determine to what extent the tests that have already been developed for native hardwoods are applicable to tropical species.

The machining properties that were investigated were planing, shaping, turning, sanding, boring and mortising. The related properties of specific gravity, cross grain, and shrinkage were also investigated because of their relation to the general utility of the woods.

Test Material

In most of the species ten or more samples were available for test. Exhaustive tests would require more material but this amount suffices to give good indications of machining and related properties. The fifteen woods, which are listed below, all came from Central America or northern South America except coigue, which came from Chile. They, of course, do not represent all of the tropical hardwoods but are all species on which the Forest Products Laboratory has received requests for information on one or more of the properties investigated.

Scientific Name	Name
Anacardium sp.	Espavel
Brosimum alicastrum group	Ujuste
Calophyllum brasiliense	Santa Maria
Carapa guianensis	Crabwood (cedro macho, andiroba)

[1] Maintained at Madison 5, Wis. in cooperation with University of Wisconsin.

Scientific Name	Name
Cordia alliodora group	Laurel
Dialyanthera sp.	Cuangare
Enterolobium cyclocarpum	Jenezero (Guanacaste)
Hieronyma alchorneoides	Pilon
Nectandra sp.	Chachajillo
Nothofagus sp.	Coigue
Prioria copaifera	Cativo
Symphonia globulifera	Mapelo
Virola sp.	Banak
Vochysia hondurensis	San Juan
Zanthoxylum sp.	Prickly yellow

A very confused situation exists concerning the common names of tropical American hardwoods. The same species often goes by different common names in different regions, and the same common name is sometimes applied to different species in different regions. In general the common names used above are those designated by the shippers and are names in common use. To insure identifying the woods beyond possibility of misunderstanding, the botanical names are used in all the tables of this report.

Test Procedure

The same general test procedure was followed as that described in detail in U. S. Dept. Agr. Tech. Bull. 824, "Machining and Related Characteristics of Southern Hardwoods." It was not practical to make all of the tests described in that bulletin, however, nor to do as much work on the effect of machining variables.

All test material was dried to 6 percent moisture content.

Machining Tests

Planing

Samples were planed at 3,600 r.p.m. at feeds of 29 and 58 f.p.m. using a 30° cutting angle. The results, which are shown in table 1, show both the planing quality of the woods and the occurrence of planing defects.

Comparison of the planing properties of the tropical hardwoods is based on the percentage of defect-free pieces and varies from 15 percent to 90 percent for different species. This compares with a range of 21 percent to 91 percent for native hardwoods and gives a good indication of the amount of sanding that may be required to prepare the woods for any fine finish.

The kinds of planing defects and their frequency of occurrence are also shown. For any given defect the occurrence may range from none up to very common in different woods.

Shaping

Tests were made on a two spindle shaper operating at 7,200 r.p.m., and cuts were made at angles that varied from parallel to grain to right angles.

The shaping properties of the woods tested, taking all defects into account, are shown in table 2. The percentage of good to excellent pieces varies in different species from 28 percent to 67 percent. This is a better showing than was made by native hardwoods, which ranged from 3 percent up to 62 percent. This difference is chiefly due to the larger proportion (among native hardwoods) of light woods that are soft and shape poorly.

Rough cutting on end grain was the most common shaping trouble as with native hardwoods. In most species it was the sort of superficial roughness that sands off without too much trouble, but in some of the lighter woods small tearouts sometimes occurred.

Turning

Turnings of uniform size and pattern were made on a modified back-knife lathe after which they were carefully examined for defects and graded for quality. Results are shown in table 3.

Quality comparison is based on the percentage of good to excellent turnings that were obtained. This varied from 40 percent to 90 percent in different tropical woods as compared with a range of 58 percent to 91 percent for 25 native hardwoods.

Surface roughness was the most common defect encountered but it can usually be removed by a little sanding. Detail refers to corners and edges that are damaged instead of being sharp and clear cut. A wood may, however, be somewhat poor in detail, but still satisfactory for turnings of sorts that do not require sharp detail. Tearouts, as the name indicates, are spots where bits of wood have torn out in turning. These are rare except in light soft woods, and in cuts approaching right angles to the grain.

Sanding

A small drum sander with garnet abrasive in the 1/0 and 3/0 grit sizes was used. After sanding the samples were examined for scratches and fuzziness and comparison of species was based on the percentage of samples in each wood that was free from these defects. Results are given in table 4.

Only one of the woods, coigue, had pores too fine to be seen with the naked eye and most of them had pores so coarse that they tended to obscure fine

scratches. This accounts for the fact that 13 of the 16 woods showed 80 percent or more of scratch free pieces when sanded with 1/0 grit. None of the woods showed visible scratches when 3/0 grit was used.

As a rule, fuzzing was more prevalent than scratching in sanding these tropical hardwoods. Although fuzzing is greatly reduced when 3/0 grit is used, most of the woods still developed some fuzzy pieces.

Boring

Two holes were bored in each sample with a small boring machine using a standard type one inch bit.

The holes were graded for smoothness of cut and measured with a plug gage for variation from the size of the bit or off size (see table 5). Percent of good to excellent holes (as far as smoothness was concerned) varied from 40 up to 100 as compared with a range of 62 to 100 for 25 native hardwoods.

The range in off size or variation from the size of the bit is practically identical with that in 25 native hardwoods.

Mortising

Two mortises were cut in each sample using a hollow chisel mortiser of the half inch size. The holes were graded for smoothness of cut and for variation from the size of the hollow chisel.

Tropical hardwoods like native ones vary widely in mortising properties and this comparison is shown in table 6. The proportion of fair to excellent mortises based on smoothness of cut ranged from 11 to 100 or about the same as for native hardwoods. The amount of offsize of the mortises (or variation from the size of the chisel) was from 0.0027 to 0.0077 or somewhat more than in native hardwoods on the average.

Related Properties

Specific Gravity

Specific gravity of the woods tested (based on oven-dry weight and green volume) is given in table 7. The lightest wood, virola, is practically the same as basswood in this respect and the heaviest, pilon, is slightly heavier than hickory. Specific gravity yields a good clue not only to strength properties but to power consumption and rate of dulling of tools in machining.

Cross Grain

The presence of spiral grain was determined by splitting small samples and making measurements. The average slope of spiral grain ranged from 2.5

percent to 8.3 percent in different woods or about the same as for native hardwoods (table 8).

Presence of interlocked grain was determined by examination and splitting but accurate measurement was not practical. This is a more extreme type of cross grain. Two-thirds of our native hardwoods have little if any interlocked grain, but 11 of 15 tropical hardwoods had more or less of it including four species in which every piece had interlocked grain.

Flat sawed boards with interlocked grain sometimes twist in drying while quarter sawed boards with the same type of grain not only season much better but often show an attractive ribbon stripe figure.

Shrinkage

Shrinkage from green to 6 percent moisture content is shown in table 9. In all woods tangential material was available for test, and radial material also was available in 8 woods. In general the shrinkage was about the same as for native hardwoods both in spread between species and in maximum and minimum species. Shrinkage is directly related to warping tendencies and hence to "ability to stay in place."

Summary and Conclusions

Table 10 gives a summary of the results of the machining tests.

Some of the species tested are consistently better than average in most respects and some are consistently poorer. Some are good in one property and poor in others. These things are equally true of native hardwoods. In general the tropical woods machined about as well as do our native hardwoods and with most of them at least it seems unlikely that machining difficulties would restrict their use much. The woods tested had a specific gravity range about equal to that between basswood and hickory. Within this range, which includes the great bulk of tropical hardwoods, the machining tests that were used appear to be equally applicable to native and tropical hardwoods.

Table 1.--Planing

Species	Planing properties	Planing defects		
	Defect-free pieces	Raised grain	Fuzzy grain	Chipped grain
	Percent			
Anacardium sp.	15	Very common	Very common	None
Brosimum alicastrum group	70	None	None	Common
Calophyllum brasiliense	43	Common	Trace	Common
Carapa guianensis	33	Trace	Trace	Common
Cordia alliodora group	75	Trace	None	None
Dialyanthera sp.	50	Trace	Trace	Trace
Enterolobium cyclocarpum	35	Common	Trace	Common
Hieronyma alchorneoides	20	Common	None	Common
Nectandra sp.	75	Common	None	Trace
Nothofagus sp.	90	None	None	None
Prioria copaifera	85	None	None	Trace
Symphonia globulifera	50	Common	None	Common
Virola sp.	60	Trace	Trace	Trace
Vochysia hondurensis	33	Very common	None	Trace
Zanthoxylum sp.	75	None	None	Trace

Table 2.--Shaping

Species	Shaping properties	Shaping defects		
	Good to excellent pieces	Rough end grain	Raised grain	Chipped grain
	Percent			
Anacardium sp.	50	Very common	Common	Trace
Brosimum alicastrum group	60	Very common	None	Trace
Calophyllum brasiliense	45	Very common	Common	Trace
Carapa guianensis	28	Very common	Very common	Trace
Cordia alliodora group	50	Very common	Common	None
Dialyanthera sp.	40	Very common	Very common	None
Enterolobium cyclocarpum	45	Very common	None	Trace
Hieronyma alchorneoides	40	Very common	None	Trace
Nectandra sp.	50	Very common	Common	None
Nothofagus sp.	67	Trace	None	None
Prioria copaifera	50	Very common	Trace	None
Symphonia globulifera	40	Very common	Common	None
Virola sp.	45	Very common	Very common	None
Vochysia hondurensis	43	Very common	Common	Trace
Zanthoxylum sp.	50	Very common	None	None

Table 3.--Turning

Species	Turning properties	Turning defects		
	Good to excellent pieces	Surface roughness	Poor detail	Tearouts
	Percent			
Anacardium sp.	70	Common		None
Brosimum alicastrum group	90	Trace		None
Calophyllum brasiliense	70	Common	X	None
Carapa guianensis	70	Common		None
Cordia alliodora group	83	Common		None
Dialyanthera sp.	50	Trace	X	Few
Enterolobium cyclocarpum	75	Common		None
Hieronyma alchorneoides	80	Trace		None
Nectandra sp.	80	Common		None
Prioria copaifera	80	Trace		None
Symphonia globulifera	83	Common		None
Virola sp.	50	Trace	X	Few
Vochysia hondurensis	40	Common	X	Few
Zanthoxylum sp.	90	Trace		None

Table 4.--Sanding

Species	Scratch-free pieces		Fuzz-free pieces	
	1/0 grit	3/0 grit	1/0 grit	3/0 grit
	Percent	Percent	Percent	Percent
Anacardium sp.	100	100	0	0
Brosimum alicastrum group	33	100	67	100
Calophyllum brasiliense	88	100	0	88
Carapa guianensis	100	100	16	50
Cordia alliodora group	100	100	0	100
Dialyanthera sp.	50	100	0	80
Enterolobium cyclocarpum	85	100	36	73
Hieronyma alchorneoides	90	100	100	100
Nectandra sp.	100	100	33	67
Nothofagus sp.	0	100	20	100
Prioria copaifera	100	100	0	50
Symphonia globulifera	100	100	16	83
Virola sp.	70	100	0	80
Vochysia hondurensis	90	100	30	70
Zanthoxylum sp.	100	100	33	100

Table 5.--Boring

Species	Good to excellent holes[1]	Amount of offsize
	Percent	Inch
Anacardium sp.	70	0.0012
Brosimum alicastrum group	90	.0002
Calophyllum brasiliense	77	.0006
Carapa guianensis	86	.0011
Cordia alliodora group	100	.0015
Dialyanthera sp.	50	.0008
Enterolobium cyclocarpum	95	.0003
Hieronyma alchorneoides	100	.0020
Nectandra sp.	75	.0013
Nothofagus sp.	84	.0024
Prioria copaifera	75	.0009
Symphonia globulifera	100	.0008
Virola sp.	50	.0015
Vochysia hondurensis	62	.0010
Zanthoxylum sp.	83	.0010

[1]Based on smoothness of cut.

Table 6.--Mortising

Species	Fair to excellent holes[1]	Amount of offsize
	Percent	Inch
Anacardium sp.	90	0.0038
Brosimum alicastrum group	100	.0028
Calophyllum brasiliense	78	.0027
Carapa guianensis	72	.0028
Cordia alliodora group	75	.0032
Dialyanthera sp.	11	.0077
Enterolobium cyclocarpum	80	.0030
Hieronyma alchorneoides	100	.0028
Nectandra sp.	67	.0049
Nothofagus sp.	100	.0041
Prioria copaifera	55	.0034
Symphonia globulifera	100	.0030
Virola sp.	30	.0052
Vochysia hondurensis	75	.0043
Zanthoxylum sp.	50	.0034

[1]Based on smoothness of cut.

Table 7.--Specific gravity
(Based on oven-dry weight and green volume)

Species	Mean	Minimum	Maximum
Anacardium sp.	0.463	0.403	0.540
Brosimum alicastrum group	.620	.575	.680
Calophyllum brasiliense	.490	.444	.530
Carapa guianensis	.496	.427	.580
Cordia alliodora group	.489	.460	.510
Dialyanthera sp.	.351	.313	.416
Enterolobium cyclocarpum	.456	.392	.546
Hieronyma alchorneoides	.651	.580	.700
Nectandra sp.	.422	.395	.465
Nothofagus sp.	.542	.498	.595
Prioria copaifera	.416	.376	.477
Symphonia globulifera	.544	.470	.593
Virola sp.	.410	.380	.465
Vochysia hondurensis	.415	.383	.456
Zanthoxylum sp.	.588	.505	.683

Table 8.--Cross grain

Species	Spiral grain Percent of slope[1]	Interlocked grain Percent of pieces
Anacardium sp.		100
Brosimum alicastrum group	8.3	25
Calophyllum brasiliense	6.5	50
Carapa guianensis	7.7	50
Cordia alliodora group	3.1	0
Dialyanthera sp.	6.7	5
Enterolobium cyclocarpum		100
Hieronyma alchorneoides		100
Nectandra sp.	4.0	67
Nothofagus sp.	2.5	0
Prioria copaifera	3.4	0
Symphonia globulifera	5.5	40
Vochysia hondurensis	6.2	50
Zanthoxylum sp.	4.4	0

[1]Applies only to pieces that are free from interlocked grain.

Table 9.--Shrinkage (from green to oven-dry)

Species	All samples	Radial only	Tangential only
	Percent	Percent	Percent
Anacardium sp.	4.6	4.1	5.8
Brosimum alicastrum group	6.9	.....	6.9
Calophyllum brasiliense	8.7	.....	8.7
Carapa guianensis	7.6	6.4	9.3
Cordia alliodora group	6.5	.....	6.5
Dialyanthera sp.	8.6	.....	8.6
Enterolobium cyclocarpum	4.5	3.0	5.4
Hieronyma alchorneoides	5.6	4.8	6.4
Nectandra sp.	5.2	4.1	6.2
Nothofagus sp.	8.6	.....	8.6
Prioria copaifera	5.2	4.4	5.6
Symphonia globulifera	7.4	.....	7.4
Vochysia hondurensis	3.6	2.8	6.5
Zanthoxylum sp.	6.7	.....	6.7

Table 10.--Summary of machining properties

Species	Planing defect-free pieces	Shaping good to excellent pieces	Turning good to excellent pieces	Sanding fuzz-free pieces	Boring good to excellent pieces	Mortising fair to excellent pieces
	Percent	Percent	Percent	Percent	Percent	Percent
Anacardium sp.	15	50	70	0	70	90
Brosimum alicastrum group	70	60	90	100	90	100
Calophyllum brasiliense	43	45	70	88	78	78
Carapa guianensis	33	28	70	50	86	72
Cordia alliodora group	75	50	83	100	100	75
Dialyanthera sp.	50	40	50	80	50	11
Enterolobium cyclocarpum	35	45	75	73	95	80
Hieronyma alchorneoides	20	40	80	100	100	100
Nectandra sp.	75	50	80	67	75	67
Nothofagus sp.	100	67	.....	100	84	100
Prioria copaifera	85	50	80	50	75	55
Symphonia globulifera	50	40	83	83	100	100
Virola sp.	60	45	50	80	50	30
Vochysia hondurensis	33	43	40	70	62	75
Zanthoxylum sp.	75	50	90	100	83	50
Mean of 15 tropical hardwoods	53	47	73	76	81	72
Mean of 25 native hardwoods	61	25	79	62	89	70