Properties of Some Papua New Guinea Woods in Relation to Manufacturing Processes

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In view of an increasing concern with the utilization of underutilized tropical woods, the Forestry and Forest Products Research Institute of Japan has carried out a series of studies on properties of woods of New Britain Island and on manufacturing of wood products from them. This paper presents the results obtained[1,2] in a summarized form.

Sample trees and test items

Sample trees were collected from two sites of the Island with the cooperation extended by the Department of Forests, Papua New Guinea, and a local commercial wood enterprise. The samples totalled 58 species or 89 trees (about 160 m^3 of log volume). Of them, 42 species, 50 trees, with large diameter were used for the tests listed below.

1) *Lumber processing*
   - 11 Band sawing (sawn surface qualities and maximum feed speed applicable with slight wander)
   - 12 Kiln drying (drying defects, drying time and recommended drying schedule)
   - 13 Planing by rotating knife (cutting force, surface qualities and knife life)
   - 14 Gluing (dry and wet bond strength of the panels glued with various adhesives)
   - 15 Painting (curing time of a resin varnish on wood and crack of paint film under accelerated conditions)
   - 16 Bending by Thonet method (radius of curvature applicable without bending failure)
   - 17 Nailing (driving and withdrawal resistances, splitting tendency during nailing)

2) *Veneer and plywood making*
   - 21 Veneer cutting (lathe check, roughness of cut surface and some strength properties related to veneer cutting)
   - 22 Veneer drying (drying rate, tangential shrinkage and warping of veneer)
   - 23 Veneer gluing (glue bond qualities of the plywoods glued with various adhesives)

3) *Manufacturing of boards*
   - 31 Particleboard (machinability in shaving, gluability and characteristics of board)
   - 32 Hardboard (properties of board made under various sizing conditions)
   - 33 Inhibition of cement hardening (compressive strength of cement-wood-powder block)

4) *Pulping*
   - 41 Fiber morphology
   - 42 Pulping (characteristics in pulping, properties of unbleached and bleached sulphate pulps)

5) *Charcoal making (properties of charcoal)*

6) *Properties of wood as related to utilization*

Table 1. Wood characteristics of 42 species

Sample No.	Species	1) Basic density	2) Color	3) Extrac- tives	4) Shrink- age	5) Strength	6) Permea- bility	7) Stain	8) Decay
2	*Alstonia scholaris*	240	−	2	8	420	120	++	++
15	*Antiaris toxicaria*	242	−	2	7	440	100	++	++
29	*Pterocymbium beccarii*	256	−	2	10	420	330	++	+++
8	*Octomeles sumatrana*	267	+	2	10	530	30	−	++
16	*Artocarpus incisus*	280	−	3	11	460	80	++	+++
1	*Spondias dulcis*	291	−	3	12	550	130	++	(−)
202	*Spondias dulcis*	301	−	3	9	530	150	++	+++
218	*Sterculia parkinsonii*	301	−	2	9	550	120	+	+++
22	*Evodia elleryana*	313	−	2	9	660	120	++	++
217	*Ailanthus integrifolia*	315	−	2	11	630	140	++	+++
204	*Endospermum moluccanum*	320	−	2	10	650	130	++	+++
12	*Cryptocarya massoy*	330	−	3	10	580	120	++	++
21	*Anthocephalus cadamba*	347	−	4	11	690	80	++	++
6	*Terminalia solomonensis*	350	+	2	9	820	60	−	+
213	*Parartocarpus venenosus*	355	−	2	11	640	200	++	+++
11	*Calophyllum vexans*	360	+	3	11	770	40	−	−
28	*Planchonella thyrsoidea*	369	−	2	12	750	80	++	++
203	*Sloanea insularis*	372	−	4	11	750	60	+	+
27	*Palaquium erythrospermum*	379	+	3	13	690	90	−	+
212	*Dysoxylum arnoldianum*	381	−	3	10	690	200	+	+
7	*Terminalia solomonensis*	381	+	2	10	810	70	−	+
5	*Terminalia solomonensis*	382	+	2	10	740	40	−	+
9	*Elaeocarpus sphaericus*	395	−	3	11	820	30	−	++
18	*Eucalyptus deglupta*	402	+	2	13	770	40	−	+
211	*Amoora cucullata*	419	++	4	14	760	50	−	−
207	*Litsea irianensis*	427	−	4	11	790	120	+	++
30	*Celtis kajewskii*	464	−	2	11	1, 040	110	++	+++
19	*Eucalyptus deglupta*	470	+	4	14	1, 020	40	−	+
23	*Pometia pinnata*	480	+	4	14	1, 010	30	−	−
3	*Canarium indicum*	484	+	3	12	940	70	+	+
20	*Syzygium sp.*	484	++	9	16	800	30	−	+
201	*Dracontomelon puberulum*	493	+	6	10	1, 010	40	−	−
4	*Terminalia calamansanai*	493	+	4	13	1, 160	70	−	+
17	*Eucalyptus deglupta*	499	+	2	16	900	40	−	+
26	*Pometia sp.*	504	+	4	15	1, 100	40	−	−
208	*Castanospermum australe*	510	++	16	11	800	50	−	−
205	*Pimelodendron amboinicum*	543	++	2	12	1, 000	200	++	++
14	*Dysoxylum gaudichaudianum*	551	−	1	15	1, 200	150	++	+
220	*Vitex cofassus*	553	+	11	11	1, 030		−	−
219	*Celtis luzonica*	560	−	2	12	1, 280	120	+	+++
215	*Neonauclea maluensis*	565	+	4	12	1, 000	60	−	−
209	*Pterocarpus indicus*	583	++	15	8	1, 100	60	−	−
216	*Burckella macropoda*	585	++	5	13	1, 230	70	−	−
13	*Intsia bijuga*	591	++	11	11	1, 600	50	−	−
206	*Garcinia latissima*	593	−	8	15	1, 060	100	−	−
25	*Pometia pinnata*	600	++	6	14	1, 150	30	−	−
24	*Pometis pinnata*	601	+	6	17	1, 220	40	−	−
210	*Aglaia litoralis*	613	++	7	12	1, 470	40	−	−
10	*Homalium foetidum*	673	++	4	14	1, 530	50	−	+
214	*Maranthes carymbosa*	798	+	1	19	1, 630	80	−	−

Notes 1) Oven-dry weight / green volume (kg/m³)
2) Lightness of wood color at the part about 2/3 of radius from pith.
\# dark, + moderately dark, − light
3) The amount of extractives by successive extraction with 4 organic solvents (%)
4) Volumetric shrinkage from green to oven-dry (%)
5) Modulus of rapture in static bending (kg/cm²)
6) Water absorption in radial direction (mg/cm²/day)
7) Discoloration by blue stain
8) Degree of decay by 3 test fungi

61 Log qualities (interlocked grain, brittle heart, and split after bucking, water content, etc.)
62 Physical properties (density, shrinkage and water absorption)
63 Strength properties in static and impact bending
64 Decay durability (weight loss of wood block attacked by various test fungi) and treatability
65 Chemical components (lignin, holo- and α-cellulose, ash, etc.)
66 Solubilities in n-hexane, ether, aceton and methanol by successive extraction
67 Chemical discoloration (iron stain, alkaline stain, acid stain and discoloration by exposure)

Small sample trees of 30 species were mostly subjected to the manufacturing tests for several kinds of board (particleboard, wet process hardboard, and dry process fiberboard) and to the pulping tests with mixed species.

Results

1) Wood color in relation to other properties

A part of the results obtained with the test item 6 is abstracted in Table 1. Although it is well known that many properties of woods are closely related to wood density, the lightness of wood color is taken as a convenient criterion for classifying logs in many cases in the course of marketing. The comparison made, therefore, between light-colored and dark-colored woods in Table 1 gave an apparent tendency that the former shows (1) less extractives by organic solvents, (2) higher permeability for liquid such as water, and (3) higher susceptibility to fungal attack such as decay and blue stain than those of the latter. Thus, the wood color can be regarded as a useful criterion in classifying logs of many different species with respect of these properties.

Table 2. Species grouping by density and lightness of color

Basic density (kg/m³)	Number of species		
	Light color	Dark color	Total
~320	9	1	10
330~560	11	13*	24*
565~	1	8*	9*
Total	21	21	42

* *Pometia* is counted as a species in each number with asterisk

By grouping 42 species tested in this study according to their basic density and lightness of color, Table 2 was obtained. It shows that the low density range is dominated by light-colored woods whereas the higher density range is dominated by dark-colored woods, with the medium density range composed of both light and dark-colored woods.

2) Workability

Based on results of the test for sawing and processing of lumbers, easiness of machining, drying, gluing, etc., was estimated as shown in Table 3. No particular difficulties were observed with sawing, except a sample No. 214, a high density wood. In kiln drying, No. 1, 17, 18, 208, etc. were apt to collapse, No. 10, 215, etc. surface check, No. 20, 203,

Table 3. Workabilities and suitabilities for the products making

Sample No.	Workability [1]							Plywood making [2]			Board making [3]			Pulping [4]	Char-coal making
	11	12	13	14	15	16	17	21	22	23	31	32	33	42	
2	○	○	○	○	○	××	○	○	○	○	××	○	○	×	×
15	○	○	○	○	○	××	○	×	○	×	××	×	×	×	×
29	○	○	—	×	○	××	○	×	○	××	××	×	○	○	×
8	×	○	○	○	○	××	○	×	○	○	×	○	○	○	×
16	○	○	○	○	○	××	○	○	×	○	×	×	○	○	×
1	○	××	○	○	○	××	○	××	×	○	×	○	×	×	×
202	○	○	○	○	○	××	○	×	×	○	××	×	○	○	×
218	○	○	○	○	○	××	○	○	○	×	○	×	○	○	×
22	○	○	○	○	○	××	○	○	○	○	○	○	○	○	×
217	○	○	○	○	○	××	○	×	○	○	○	○	○	○	×
204	○	—	○	○	○	—	—	—	—	—	—	—	—	—	—
12	×	○	○	○	○	××	○	×	○	○	○	○	×	○	×
21	○	○	○	○	○	××	○	○	○	○	○	×	×	○	×
6	○	○	○	○	○	××	○	○	○	○	○	○	○	○	×
213	○	○	○	—	—	××	—	○	×	××	×	—	—	—	—
11	○	○	×	○	○	××	○	○	○	○	○	○	○	○	×
28	○	○	○	○	○	××	○	○	○	○	○	○	○	○	×
203	○	×	○	○	○	××	○	○	○	○	○	×	○	○	×
27	○	○	○	○	○	××	○	○	○	○	○	○	○	○	×
212	○	○	×	○	○	××	○	○	○	×	××	○	○	○	×
7	○	○	×	○	○	××	○	○	○	(×)	○	○	○	○	×
5	○	○	○	○	○	××	○	○	○	○	○	○	○	○	×
9	○	○	○	○	○	××	○	○	○	○	○	×	○	○	×
18	○	○	×	○	×	××	○	××	○	○	○	○	○	○	×
211	○	○	×	○	○	××	○	○	××	○	○	○	○	×	×
207	—	×	—	○	××	—	—	—	—	—	—	—	—	—	—
30	○	○	○	×	○	××	○	○	○	××	×	×	×	×	×
19	○	○	○	×	○	××	○	×	○	○	○	○	○	○	×
23	○	○	○	○	○	×	○	○	○	○	○	○	×	×	×
3	○	○	○	○	○	××	○	○	○	○	○	○	○	○	×
20	○	××	×	○	×	××	○	○	○	××	○	○	×	×	×
201	○	×	○	○	×	××	○	—	—	—	—	—	—	○	×
4	○	○	○	○	○	××	○	○	○	(××	○	○	○	○	×
17	○	○	—	○	○	××	—	×	○	○	×	○	○	○	×
26	○	○	○	○	○	×	○	○	○	○	×	○	×	×	×
208	○	××	—	○	××	×	○	—	—	—	—	—	—	—	—
205	○	○	○	○	○	××	○	○	××	○	×	×	○	○	×
14	○	○	○	○	○	××	○	○	○	○	○	○	×	×	×
220	—	×	—	—	—	×	—	—	—	—	×	—	—	—	—
219	○	○	○	○	××	××	○	○	○	××	×	×	○	○	○
215	○	○	○	○	○	×	○	○	×	○	○	○	××	×	○
209	—	○	—	×	○	××	○	—	—	—	—	—	—	—	—
216	○	○	○	○	○	×	×	○	○	○	○	○	○	×	○
13	○	○	○	○	○	×	×	—	—	—	×	×	○	○	○
206	○	—	—	○	×	—	—	○	○	×	○	—	—	—	—
25	○	○	×	○	○	×	○	○	○	○	○	×	×	×	○
24	○	○	×	○	○	×	○	○	○	○	×	×	×	×	○
210	×	×	×	○	○	××	×	—	—	—	○	○	○	○	○
10	×	○	○	○	×	××	×	—	—	—	××	○	○	×	○
214	××	—	×	○	○	—	—	—	—	—	××	—	—	—	—

Notes 1) Process No. 11: Band sawing, 12: Kiln drying, 13: Planing, 14: Gluing, 15: Finishing, 16: Wood bending, 17: Nailing
2) Process No. 21: Rotary veneer cutting, 22: Veneer drying, 23: Veneer gluing
3) Process No. 31: Particleboard making, 32: Cement board making, 33: Wet process hardboard making
4) Process No. 42: Sulphate pulping
○, × or (×), ×× or (××) denote "suitable", "possible", "difficult" respectively.
In veneer gluing, × and ×× indicate any difficulty in urea resin gluing, whereas (×) and (××) those in phenolic resin gluing.

208, etc. honey comb, and No. 20 and 208 required extremely long drying time. In planing, torn grain was observed with No. 20, 24, 25, 210, etc., raised grain with No. 17, 18, etc., and marked blunting of knife edge with No. 214.

Curing of coated varnish (an unsaturated polyester resin) in the finishing took especially long time with No. 20 and 207, and the extratcives responsible for this trouble were identified. Wood bending was generally difficult, but No. 23—26, and 215 were found to belong to the group with relatively easy bending. In driving common nail, it was recognized that the higher the wood density the more the occurrence of splits was.

3) Plywood making

As to the rotary veneer cutting, woods with medium density were judged best because of the easiness of cutting and veneer quality. However, No. 17—19 hardly gave good veneers in spite of their medium density, whereas No. 23—26 showed good test results in spite of their relatively high density. In veneer drying, the drying duration was influenced by water content/cm^3 of green wood, etc., and the longest duration shown by No. 213 was more than twice of the shortest one shown by No. 11. Some species, including No. 202, showed somewhat large warping. As to the bond strength of veneer, light-colored woods such as No. 29, 213, 219 etc. when urea resin was used, and dark-colored woods like No. 4, 20, etc. when phenolic resin was used showed slightly low values.

4) Manufacturing boards

In the test for manufacturing particleboard, many troubles occurred when low density or high density woods were used as the raw material, showing greater differences among species in manufacturing easiness and quality of products than in the case of wet process hardborad. However, the material composed of different woods mixed at the rate of species components in the forest gave a good quality for the above two kinds of board, dry process fiberboard and fiber molding. Inhibited hardening of cement in the manufacturing of cement-woodpowder blocks occurred more frequently with light-colored woods.

5) Pulping and charcoal making

As no species showing particular difficulties for pulping by sulphate method was found, all species were regarded eligible to be used as the raw material for paper-making pulp. Sulphate pulp and neutral sulphite semi-chemical pulp produced from mixed species were also very good in their quality.

In charcoal making, it was made clear that hard charcoal for domestic or industrial use can be produced from woods with basic density higher than 550 kg/m^3, and soft charcoal as the raw material for charcoal briquettes can be produced from other woods.

Conclusion

Regarding the industrial utilization of woods of New Britain Island, it may be concluded as follows:

Almost all species can be used for sawlogs, but light-colored woods should be treated to control fungus and insect damages immediately after the conversion. Tree species which aptly cause troubles in processing such as drying and so on may have a limited scope of utilization, unless processing methods could be improved.

For plywood, species belonging to the group of medium density, dark-colored woods are generally suitable. Several species even among light-colored woods are also suitable. Low density woods can be used for core stock. Among the high density woods, those with good appearance are used for sliced veneer, and others are used for sawlogs.

Almost all species can be used as the raw material for making various kinds of board or for pulping as far as the mixed species are employed. However, attention must be called to the processing conditions or mixing rate of species in the manufacturing of particleboard and cement-woodpowder blocks when the species which aptly cause troubles are used. Charcoal making from high density woods having less utility value is considered to be able to establish a small scale local industry.

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