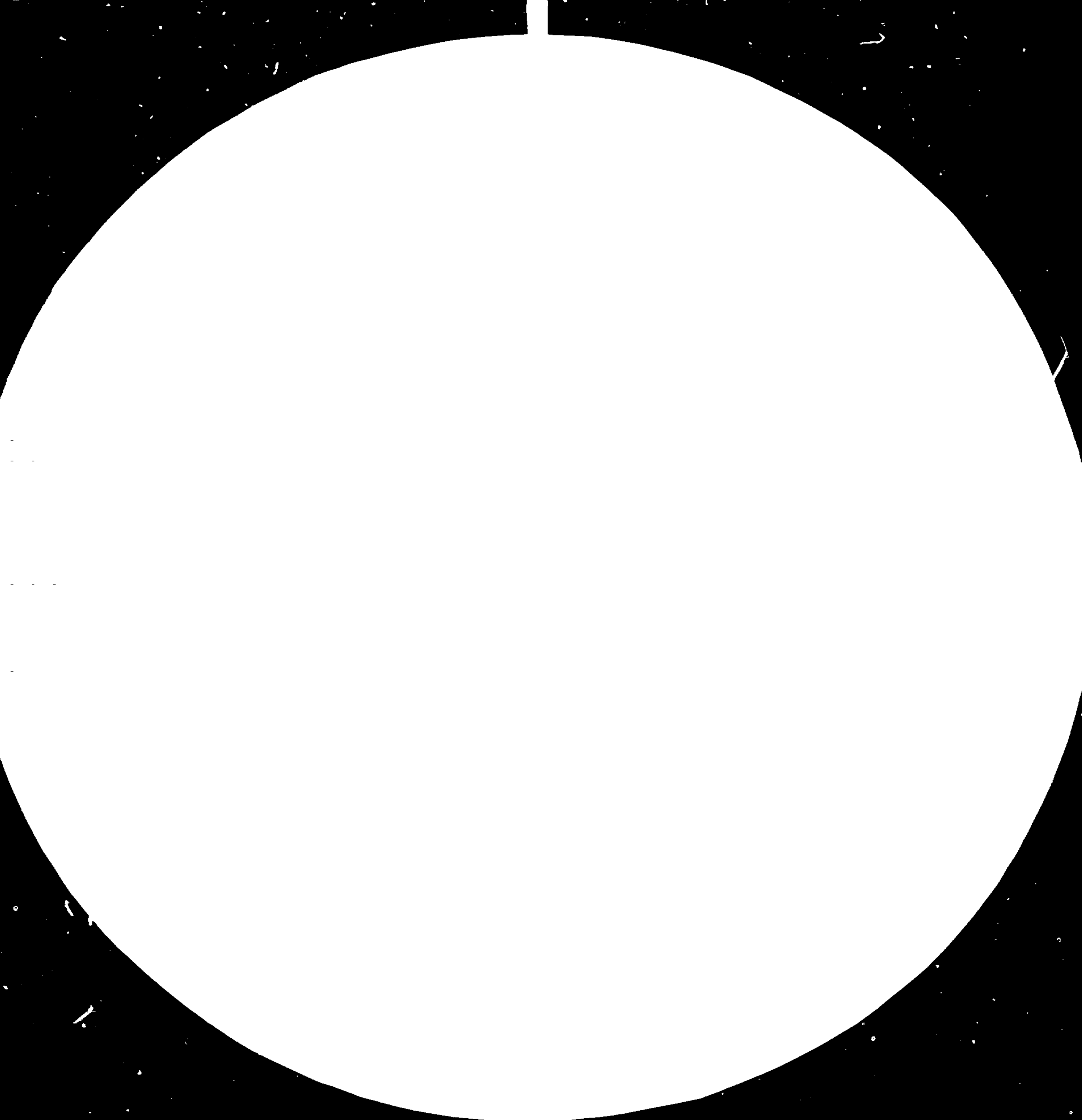

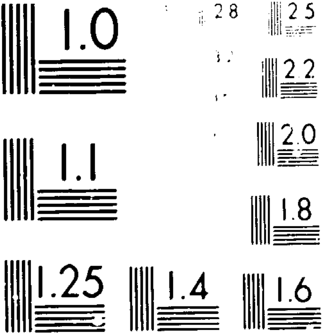

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RESEARCH STUDIES ON TROPICAL HARDWOODS FOR PULP AND PAPER MANUFACTURE *

by

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and

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INTRODUCTION

The Philippines, like most other tropical countries, has been richly endowed with abundant natural forest resources. These forests are very rich in valuable timber, rattan, resins, and other forest products. The Philippines has a total land area of 30 million hectares (M has.) and, as of 1977, there are still about 9.8 M. has. of production forests with an estimated volume of around 1.5 billion cubic meters (m^3) (1).[1/] These figures show that this country has ample forest resources which could supply the requirements of several integrated pulp and paper mills. Furthermore, these forests, if properly managed, protected, and developed could supply the raw material requirements for the perpetual operation of integrated pulp and paper mills.

1/Underscored numbers in parentheses refer to literature cited.

The timber stands of tropical countries occur as heterogenous mixtures of several hardwood species. As such, the determination of the feasibility of producing pulp and paper from these hardwoods presents a complicated problem due to the variety of wood species available and the wide variability in their physical, chemical, anatomical, and morphological properties. This problem is further aggravated by the fact that the composition of the mixed hardwoods or the percentage of each species varies from one forest area to another.

In the utilization of tropical hardwoods for pulp and paper manufacture, it would be more practical to use these as mixture as they naturally occur in the forest. However, due to the wide range of the properties of these hardwoods, some of these may be unsuitable/undesirable for pulp and papermaking. Hence, it is important to study, as much as possible, the pulping qualities of individual species or group of species with similar characteristics to determine the promising ones and to eliminate the less desirable species. Again, the difficulty in the separation of these unwanted species either in the forest or woodyard can also pose some problems. However, these unwanted species may only be really undesirable if these are present in reasonably large quantities to affect the whole batch of the raw materials.

RESEARCH ON PHILIPPINE TROPICAL HARDWOODS

For the purpose of this paper, researches on Philippine tropical hardwoods were classified into four groups. These include studies on: (a) commercially-exploited species; (b) non-commercial/lesser-used hardwoods; (c) plantation and fast-growing species; and (d) utilization of mixed hardwoods.

A. Commercially-Exploited Hardwoods

This group includes a little more than 50 timber species which are well known for their uses in commerce such as in building construction, furniture, poles and piles, railway sleepers, and other uses. Most important of these hardwoods are the seven species, belonging to the "Philippine mahogany" sub-group which accounts for more than 50% of the total timber stands of the country (2).

Since this "Philippine mahogany" includes the premier species of the forests, it would be advisable to use only the wastes of these species which include logging wastes and residues, and also manufacturing residues.

A study, conducted by FORPRIDECOM (3) has shown that for every 100 m^3 of timber removed from the forest, about 80 m^3 of forest wastes and residues are left in the form of tops, branches, butt trims, stumps, abandoned logs and residual trees. This means that 44% is left in the forest as wastes and residues.

This study also determined the amount of manufacturing residues generated in the sawmilling and veneer and plywood operations. Studies on sawmilling operations revealed that lumber conversion was only 48% of the log input and the 52% accounts for sawdust, slabs, edgings, lumber trims and defective materials (3).

In plywood manufacture, recovery was only 40%, while residues (round-ups, spur trims, log centers, green-veneer trims, and dry-end residues) amounted to 53%, and defects and shrinkage was 7%.

In 1975, Philippine log production was 6,988,000 m^3 and this increased to 8,645,000 m^3 in 1976. Since then, log production declined annually until in 1979 production was only 6,578,000 m^3 (4).

On the other hand, log exports continued to decline from 4,595,066 m^3 in 1975 to 2,331,297 in 1976 and finally to only 1,247,973 in 1979 (4). This decline in log exports was due to the government policy of eventually banning the exportation of logs. As such, the local consumption of logs for conversion to processed wood products increased considerably from 2,392,934 m^3 in 1975 to 5,330,027 m^3 in 1979, Average consumption of logs for the 5-year period was 4,964,293 m^3.

Based only on 50% wastes generated in manufacturing operations, about 2.5 million m^3 of wood are wasted. In addition to this, about 5 million m^3 of forest wastes and residues are still available in the forest area. Assuming that only 30% of these wastes would be economically feasible to retrieve, more than 2 million m^3 of wood wastes would be available for the pulp and paper industry.

Studies, conducted at FORPRIDECOM on the utilization of veneer wastes, cores, log ends, sawmill-waste slabs and edgings, etc., have shown the potential of these wastes for pulp and paper (5-7). At present, there are three integrated mills which use these wastes in their operations.

The specific gravity, morphological and chemical properties of some commercial hardwoods (8-13) are given in Table 1. Table 2 shows the kraft-pulping data and the physical properties of the pulp handsheets of the individual hardwoods (14-16). Based on these results, only apitong appears to be the least desirable species in the group.

B. Non-Commercial/Lesser-Used Species

During logging operations, only the well-known commercial species are extracted while the non-commercial/secondary species are left in the forest. The volume of these lesser-known species can also be considered sizable and can be a potential source of material for the pulp and paper industry. In view of this, FORPRIDECOM conducted studies to determine their suitability for pulp and paper production.

Table 1 also shows the specific gravity, fiber dimensions, and the proximate chemical composition of 24 non-commercial hardwoods (11,12,17) while the sulfate-pulping data and the properties of the handsheets of these species are presented in Table 2. These results show that anuling, balobo, bolon and dita are the only species which gave low pulp-strength properties among the non-commercial hardwoods studied (18-20).

C. Plantation and Fast-Growing Hardwoods

Due to the fast rate of growth of most species belonging to this group, this can be considered as one of the most important renewable resources for the pulp and paper industry. The government has realized the importance of fast-growing species, not only to the reforestation program of the country but, also, to feed the raw material requirements of wood-using industries, especially the pulp and paper industry. In view of this, the government has offered incentives to those interested in the establishment of large-scale industrial tree plantations. Such incentives include granting of leases for at least 25 years to a maximum of 50 years for industrial tree plantations with a rental not to exceed ₱1.00 (US $0.13) per hectare, forest charges of 6% of the current value of the wood harvested, and other reduced tax benefits (21).

Furthermore, government-financing institutions grant loans to qualified tree farmers at the rate of ₱1,300 - ₱2,000 (US $ 173-267) per hectare (22). Due to these various incentives, there is now a massive reforestation program in Mindanao, being undertaken by the various wood-processing plants. This endeavor has been so profitable that tree farming has become popular in areas around wood-processing centers. It has been reported that a hectare of *Albizia falcataria* plantation can easily net P 20,000 (US $2,667) a year. It was also reported that an integrated pulp and paper mill supports 3,000 tree farmers, tilling more than 20,000 hectares (23).

The utilization of plantation-grown species for pulp and paper has several advantages. Among these, are the following:

1. Fast rate of growth of species make short cutting cycle possible;
2. As such, land-area requirements will be less for the same wood yield compared to traditional wood species;
3. Clear-cut logging practices are possible, thus reducing harvesting costs;
4. Most species produce coppice thus eliminating the necessity of periodic replanting;
5. Only desirable species may be propagated; and
6. Most important of all, more uniform pulp quality can be obtained in the mill due to better control of material input.

Results of studies at FORPRIDECOM on the physical, morphological, chemical, and kraft-pulping characterisitics of 11 plantation and fast-growing species are also presented in Tables 1 and 2 (9. 10, 12, 16, 22, 24, 26). These results show that all the species studied are good raw materials for pulp and papermaking.

D. Utilization of Mixed Tropical Hardwoods

As mentioned earlier, the most practical approach to the utilization of tropical hardwoods for pulp and paper would be to use these as they occur in the forest area. However, due to the number of species available in a certain forest, it would be advisable to group species according to their papermaking characteristics. With this papermaking classification, it would be possible to think more in terms of groups of species rather than in terms of individual species.

A study was undertaken to determine the pulping and papermaking characteristics of a naturally-occuring mixture of Philippine hardwoods. Table 3 presents the kraft-pulping data and the physical properties of the pulp handsheets prepared from this mixture. It may be noted that the mixture was subdivided into two lots. Lot 1 represents the low specific gr vity (sp. gr.) hardwoods, possessing fibers with thin-cell walls ar . all belong to the Philippine mahogany group. Lot 2 includes 4 species with high sp. gr. (above 0.50 g/m^3) and with thick-walled fibers.

As shown in Table 2, all the kraft pulps from species, belonging to the Philippine mahogany group, possess good strength properties. On the other hand, the denser species with thick-walled fibers produce pulps with either low or moderate strength. When these two lots were mixed and cooked together, the resulting pulps were of moderate strength and of acceptable quality. This proves that the less desirable species can also be utilized when these are blended with the more desirable species which have good burst, fold, and tensile strengths.

The same trend was observed when these pulps were converted into kraft-wrapping papers. When 20% commercial softwood kraft pulp was blended with the pulp from the hardwood mixture (Lots 1 & 2), the tearing resistance was considerably improved, producing papers with properties comparable to commercial kraft-wrapping papers.

Studies were also conducted on the blending of hardwood pulps with pulps from other fibrous materials such as softwoods, bamboos, abaca, and other hardwoods for the production of bond, kraft wrapping, bag, and newsprint (7, 27, 31). Results of these studies have shown that, for most practical purposes, the strength properties of the paper produced from them can be predicted by using the weighted-average method, based on the percentage of each individual pulp component.

SUMMARY

In the utilization of mixed-tropical hardwoods for pulp and paper, it would be advisable to have the technical information (fiber dimensions, chemical composition, and pulping and papermaking properties) in the various individual species available. With this information, species can be grouped according to their papermaking characteristics. This grouping could then provide the basis for quality-control measures as the properties of mixture of species could, for most practical putposes, be predicted from the properties of individual species. Furthermore, less desirable species would only be harmful if present in large quantities to greatly affect the over-all pulp quality.

Looking ahead, fast-growing plantation species will soon be the main raw material resource of the pulp and paper industry, based on tropical hardwoods.

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Table 1. Specific Gravity, Fiber Dimensions and Proximate Chemical Composition of Some Philippine Hardwoods

Species	Specific gravity g/cm^3	Fiber dimensions: Fiber length mm	Cell-wall thickness	Lumen width mm	Runkel ratio b/	Proximate chemical composition a/: Holocellulose %	Pentosans %	Lignin %	Solubilities in: Alcohol Benzene %	Hot water %	1% NaOH %	Ash %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Commercial Hardwoods												
1. "Philippine mahogany"												
a. Almon (Shorea almon Foxw.)	0.39	1.51	0.004	0.018	0.44	62.6	13.7	29.9	5.2	4.3	14.6	0.3
b. Bagtikan (Parashorea plicata- Brandis)	0.51	1.20	0.004	0.020	0.40	66.5	15.2	27.7	3.1	2.9	11.9	1.2
c. Mayapis/ Shorea squamata (Turcz.) Dyer/	0.38	1.42	0.004	0.021	0.38	60.0	11.9	32.8	6.5	4.3	14.8	0.4
d. Red lauan (Shorea negrosensis Foxw.)	0.47	1.72	0.005	0.022	0.45	53.2	17.6	37.7	6.2	4.8	22.1	0.3
e. Tangile/ Shorea polysperma (Blanco) Merr./	0.45	1.23	0.004	0.017	0.51	59.5	10.7	25.2	3.7	2.5	13.1	0.3
f. Tiaong (Shorea agsaboensis Stern)	0.33	1.50	0.0034	0.024	0.42	65.9	11.5	30.8	2.1	1.0	15.2	0.2
g. White lauan/ Pentocone contorta (Vid.) Merr. & Rolfe/	0.43	1.37	0.004	0.018	0.41	65.0	15.0	28.6	3.9	2.8	13.2	0.8
2. Apitong (Dipterocarpus grandiflorus Blanco)	0.63	1.56	0.010	0.010	2.00	59.3	15.9	28.9	8.2	6.4	21.1	1.5
3. Guijo / Shorea guiso (Blanco) Blume/	0.70	1.24	0.005	0.005	2.00	62.0	16.0	29.4	5.1	1.7	15.7	1.8

(1)	(2)	(3)	(4)	(5)
4. Manggachapui (Hopea Acuminata Merr.)	0.63	1.31	0.0065	0.008
5. Manggasinoro (Shorea Philippinensis Brandis)	0.51	1.00	0.004	0.019
6. Palosapis / Anisoptera thurifera (Blanco) Blme /	0.52	1.65	0.0095	0.006
7. Taluto / Pterocymbium tinctorium (Blanco) Merr. /	0.30	1.39	0.004	0.025
8. Yakal gisok (Shorea guiso Foxw.)	0.84	1.43	0.009	0.004
B. Non-Commercial Hardwoods				
1. Agoho (Casuarina equisetifolia L.)	0.80	1.67	0.0065	0.004
2. Anabiong / Trema orientalis (L.) Blume /	0.30	1.19	0.004	0.026
3. Anuling / Pisonia umbellifera	0.21	0.64	0.005	0.026
4. A panit (Mastixia Philippinensis Wang.)	0.49	3.47	0.012	0.017
5. Balakat-gubat / Sapium luzonicum (Vid.) Merr. /	0.51	1.27	0.006	0.021
6. Balobo / Diplodiscus paniculatum (Turcz. /	0.66	1.50	0.005	0.010

(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1.63	-	12.2	-	10.7	-	17.9	0.5
0.42	67.9	16.6	26.6	3.3	2.4	12.1	1.2
3.17	70.3	16.2	22.4	4.4	3.4	18.0	1.0
0.32	67.3	17.6	18.2	2.2	11.0	23.9	2.5
4.50	61.4	14.7	21.4	14.1	9.4	17.9	1.6
3.25	66.2	19.7	29.4	2.1	1.7	14.2	0.7
0.31	70.2	20.6	22.8	2.1	3.4	18.6	1.5
0.38	61.2	16.8	22.4	4.3	5.8	23.5	6.0
1.41	75.0	15.4	20.2	1.5	2.2	17.5	1.2
0.40	65.1	17.8	24.7	3.8	3.3	18.4	3.1
1.00	61.8	15.7	28.1	4.0	3.4	18.9	2.7

(1)	(2)	(3)	(4)	(5)	(6)
7. Balsa /Ochroma pyramidale (Cav.) Urb./	0.35	1.73	0.0045	0.022	0.41
8. Basikong (Ficus botryocarpa Miq.)	0.43	1.33	0.0055	0.014	0.79
9. Binuang (Octomeles sumatrana Miq.)	0.23	1.43	0.0040	0.030	0.27
10. Bolon /Alphonsea arborea (Blanco) Merr./	0.70	1.30	0.0060	0.010	1.20
11. Bunten (Engelhardia rigida Blume)	-	1.38	0.0040	0.033	0.24
12. Daha (Macaranga caudatofolia Elm.)	-	1.26	0.0045	0.029	0.31
13. Dita /Alstonia scholaris (L.) R. Br./	0.38	1.71	0.005	0.021	0.48
14. Dulit /Canarium hirsutum Willd. ssp. hirsutum var. hirsutum forma (Bl.) Leenh/	0.39	1006	0.005	0.016	0.63
15. Hagimit /Ficus minahassae (Teysm and de Vr.) Miq./	0.42	1.29	0.006	0.016	0.42
16. Katmon (Dillenia philippinensis Rolfe)	0.62	2.75	0.0115	0.023	1.00
17. Kupang (Parkia roxburghii G. Don)	0.36	1.15	0.0035	0.023	0.30
18. Malakalumpang (Sterculia ceramica R. Br.)	0.29	1.57	0.005	0.018	0.57
19. Malapapaya /Polyscias nodosa (Blume) Seem/	0.35	1.16	0.0050	0.020	0.50
20. Rarang /Erythrina subumbrans (Hassk.) Merr./	0.24	1.44	0.0045	0.025	0.36
21. Tan-ag (Kleinhovia hospita L.)	0.34	1.20	0.004	0.024	0.33

(7)	(8)	(9)	(10)	(11)	(12)	(13)
67.0	20.6	24.0	3.0	4.0	28.8	2.0
60.8	15.6	28.4	2.6	6.3	24.4	2.0
61.0	14.1	32.2	1.7	3.6	15.1	1.5
64.2	17.7	25.2	6.2	2.8	23.7	1.6
60.3	14.1	33.6	2.1	1.8	23.1	2.2
62.2	14.7	34.2	1.4	1.0	14.4	1.2
62.1	14.1	30.6	2.8	5.9	17.0	1.3
-	11.7	22.0	2.5	8.9	23.6	1.2
66.0	18.2	25.6	2.3	3.4	17.8	2.6
61.9	14.0	27.0	3.6	6.7	24.5	2.2
65.6	16.8	26.4	3.6	2.2	15.4	2.1
67.0	18.4	21.8	2.9	5.6	21.4	2.8
71.4	21.5	21.3	3.4	2.9	22.3	1.1
63.6	14.7	27.5	3.1	3.4	16.6	2.4
63.3	16.6	29.0	2.7	2.8	15.8	2.3

(1)	(2)	(3)	(4)	(5)
22. Tangisang-bayawak (*Ficus variegata* Blume)	0.28	1.26	0.0035	0.029
23. Toog [*Combrentondron quadrialatum* (Merr.) Merr.]	0.71	2.38	0.0070	0.014
24. Tuai (*Bischofia javanica* Blume.)	0.56	2.14	0.007	0.025
C.[2] Plantation and Fast-Growing Hardwoods				
1. African tulip (*Spathodea Campanulata* Beauv.)	0.25	0.96	0.003	0.023
2. Anabiong (*Trema orientalis* L. Blume)	0.30	1.19	0.004	0.026
3. Balsa [*Ochroma pyramidale* (Cav.) Urb.]	0.31	1.73	0.0045	0.022
4. Binuang (*Octomeles sumatrana* Miq.)	0.23	1.43	0.0040	0.0030
5. Giant ipil-ipil/ [*Lencaena leucocephala*.(Lamk.) de Wit] (K28, 1.5 years old)	0.52	1.04	0.005	0.016
6. Gubas (*Endospermum peltatum* Merr.)	0.32	1.64	0.006	0.032
7. Ilang-ilang [*Cananga odorata* (Lam.) Hook f. & Thoms]	0.29	1.02	0.005	0.028
8. Kaatoan bangkal [*Anthocephalus chinensis* (Lamk.) Rich ex Walp.]	0.33	1.43	0.005	0.024
9. Lumbang [*Aleuritis moluccana* (L.)]	0.48	1.38	0.0050	0.026

(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
0.24	60.2	15.5	29.0	3.1	4.0	19.3	3.8
1.00	56.0	13.5	37.4	3.9	0.6	22.7	1.9
0.56	44.4	11.9	39.4	1.5	3.7	31.2	1.1
0.26	61.6	15.6	21.2	4.6	8.6	19.1	1.8
0.31	70.2	20.6	22.8	2.1	1.7	14.2	0.7
0.41	67.0	20.6	24.0	3.0	4.0	18.8	2.0
0.27	61.0	14.1	32.2	1.7	3.6	15.1	1.5
0.62	72.6	20.1	22.7	1.7	2.0	-	0.9
0.38	66.2	16.6	27.7	1.9	4.2	15.4	1.3
0.36	65.9	16.6	25.8	2.8	6.5	18.4	1.5
0.42	70.2	19.6	22.5	3.2	3.2	21.1	0.9
0.39	62.5	20.5	27.1	1.8	6.4	27.1	2.2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
10. Moluccan sau [*Albizia falcataria* (L.) Fosb.]	0.25	1.04	0.0045	0.018	0.50	70.8	16.9	25.0	2.6	1.1	16.0	0.5
11. Yemane [*Gmelina arborea* Roxb.]	0.33	1.30	0.0035	0.024	0.29	71.7	18.4	21.8	3.2	2.3	13.5	1.0

a/ Percentages are based on moisture-free weight of wood.

b/ Twice thickness of cell wall divided by the diameter (width) of the lumen.

Table 2. Kraft Pulping Data [6/] and Physical Properties of Pulp Handsheets From Some Philippine Hardwoods

Species	Screened Pulp yield %	Permanganate No.	Physical properties of pulp handsheets at 350 cm^3 CSF: Burst factor	Tear factor	Folds (double) MIT	Tensile breaking length m	Sheet density g/cm	Overall Pulp Strength
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A. Commercial Hardwoods								
1. "Philippine mahogany"								
a. Almon	48.4	18.4	84	140	1,400	10,800	0.65	strong
b. Baytikan	51.0	18.1	79	116	1,200	10,200	0.69	- do -
c. Mayapis	41.1	18.2	70	132	1,100	9,500	0.66	- do -
d. Red lauan	42.2	20.2	92	120	1,800	11,400	0.67	- do -
e. Tangile	44.2	20.5	70	110	400	10,950	0.64	- do -
f. Tiaong	47.3	16.7	88	102	1,350	10,600	0.71	- do -
g. White lauan	47.7	17.6	91	112	1,800	12,700	0.70	- do -
2. Apitong	43.4	16.0	43	120	70	7,800	0.51	weak
3. Manggasinoro	47.8	15.9	63	108	800	8,900	0.69	moderately strong
4. Palosapis	44.7	12.6	63	176	800	8,750	0.56	strong
5. Taluto	46.6	12.8	84	76	1,000	10,200	0.85	- do -
6. Yakal gisok	48.2	18.0	62	130	230	9,500	0.52	moderately strong
B. Non-Commercial Hardwoods								
1. Agoho	48.1	12.0	55	86	188	8,200	0.64	moderately strong
2. Anabiong	51.8	12.0	76	63	720	11,100	0.84	strong
3. Anuling	37.4	16.1	16	35	3	4,900	0.65	weak
4. Apanit	45.7	11.3	58	175	565	8,500	0.50	moderately strong
5. Balakat-gubat	41.9	10.6	63	62	1,360	7,650	0.86	- do -

(1)	(2)	(3)	(4)	(5)
6. Balobo d/	41.3	11.6	68	111
7. Balsa	47.5	17.4	85	91
8. Basikong	42.4	14.0	66	106
9. Binuang	47.5	-	88	75
10. Bolon	42.3	18.6	42	62
11. Buntan	42.0	14.6	67	62
12. Daha	44.6	19.0	75	90
13. Dita d/	37.2	-	73	58
15. Hagimit d/	46.4	13.5	53	79
16. Katmon	37.6	16.8	60	177
17. Kupang	49.5	16.1	66	68
18. Malakalumpang d/	45.0	9.9	78	114
19. Malapapaya	46.4	-	84	98
20. Rarang	46.3	20.0	48	116
21. Tan-ag d/	42.0	18.7	72	89
22. Tangisang bayawak	43.0	16.8	72	88
23. Toog	40.9	22.3	82	133
24. Tuai e/	31.3	-	79	105
C. Plantation and Fast Growing Hardwoods				
1. African tulip	45.3	23.9	81	68
2. Anabiong	51.8	12.8	76	63
3. Balsa	47.5	17.4	85	91
4. Binuang	47.5	-	88	75
5. Giant ipil-ipil	50.3	14.4	82	81
6. Gubas	45.5	14.2	78	84
7. Ilang-ilang	45.0	15.6	68	78
8. Kaatoan bangkal	47.3	15.9	70	82
9. Lumbang d/	48.9	21.1	57	67

(6)	(7)	(8)	(9)
400	7,240	0.61	Weak
900	8,400	0.81	Strong
1,000	9,800	0.68	Strong
2,500	13,000	0.82	- do -
43	7,300	0.60	Weak
470	11,150	0.82	Strong
1,750	9,600	0.76	- do -
580	7,230	0.84	Weak
500	8,200	0.80	- do -
340	7,700	0.57	- do -
590	10,250	0.82	strong
970	10,800	0.75	- do -
480	8.950	0.82	Moderately strong
700	10,600	0.69	Strong
700	9,050	0.79	Moderately strong
590	9,500	0.75	- do -
620	10,300	0.57	- do -
1,750	10,800	0.75	strong
1,135	10,700	0.77	Strong
720	11,100	0.84	- do -
900	8,400	0.81	- do -
2,500	13,000	0.82	- do -
500	9,100	0.78	Moderately strong
900	11,600	0.71	Strong
1,050	11,200	0.77	- do -
750	13,000	0.78	- do -
1,160	7,760	0.78	Moderately strong

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
10.	Moluccan sau f/	53.8	10.9	67	70	350	10,400	0.77	strong
11.	Yemane	55.7	11.4	70	68	1,275	12,270	0.85	- do -

c/ Except as otherwise noted, pulping was done using 15% NaOH and 5% Na2S; liquor to wood ratio of 4 to 1; 1.5 hrs from room temperature to 170°C and another 1.5 hrs at 170°C.

d/ Pulped using 19.4% NaOH and 6.3% Na_2S. Other conditions are same as for footnote C.

e/ " " 20.57% NaOH and 6.86% Na_2S. - do -

f/ " " 13.3% NaOH and 6.7% Na_2S. - do -

Table 3. Kraft Pulping Data and Physical Properties of Pulp Handsheets From a Natural16 - Occurring Mixture of Philippine Hardwoods

Mixture of Species		Screened Pulp Yield %	Permanganate No.	Physical properties of pulp handsheets at 550 cm^3: Burst factor	Tear factor	Folds (double) MIT	Tensile Breaking length, m	Sheet density g/cm^3	C[illegible]ll pulp Strength
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lot 1	Proportion by weight %								
Tangile - - -	20.0								
Red lauan - -	17.0								
White Lauan -	19.6								
Mayapis - -	18.4	48.1 (For Lot 1 only)	-	80	130	700	9,800	0.75	strong
Sub-total - - -	75.0								
Lot 2									
Apitong - - -	7.4								
Palosapis - -	7.6								
Guijo [Shorea Blume] - -	5.0	48.3 (For Lots 1 & 2)	13.8	70	129	475	8,500	0.67	Moderately strong
Manggachapui (Hopea acuminata Merr.) - - -	5.0								
Sub - Total	25.0								

a/ Pulped using 15% NaOH and 5% Na_2S 4:1 liquor to wood ratio; 1.5 hr to 170°C and maintained at 170°C for another 1.5 hr.