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This report establishes the suitability of Philippine hardwoods for the manufacture of tissue and toweling papers. Fifty species of Philippine hardwoods were used to make pulps for the tissue and toweling trials. The chips were made from bark-free wood in a commercial size four-knife chipper. The nominal length of the chips was 5/8 inch, and the fines and oversize were removed prior to blending of the individual species to obtain the mixtures. The mixture for the kraft pulp contained equal amount (dry weight basis) of 47 species, and the mixture for the thermomechanical pulp contained equal amounts of the three lightest colored woods. Acceptable quality papers were made from furnishes containing 80% Philippine hardwood kraft pulp and 20% commercial long-fibered pulp. No significant changes in the quality of the papers were found in replacing half of the hardwood kraft pulp with a Philippine hardwood thermomechanical pulp.

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# TISSUE AND TOWELING PAPERS FROM MIXTURES OF PHILIPPINE HARDWOODS

By

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

# TISSUE AND TOWELING PAPERS FROM MIXTURES OF PHILIPPINE HARDWOODS

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## Summary

This report establishes the suitability of Philippine hardwoods for the manufacture of tissue and toweling papers. Acceptable quality papers were made from furnishes containing 80 percent Philippine hardwood kraft pulp and 20 percent commercial long-fibered pulp. No significant changes in the quality of the papers were found in replacing half of the hardwood kraft pulp with a Philippine hardwood thermomechanical pulp.

## Experimental

### Wood Mixtures

Fifty species of Philippine hardwoods were used to make pulps for the tissue and toweling paper machine trials. The chips were made from bark-free wood in a commercial size, four-knife chipper. The nominal length of the chips was 5/8 inch, and the fines and oversize were removed prior

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

to blending of the individual species to obtain the mixtures. The mixture for the kraft pulp contained equal amounts (dry-weight basis) of 47 species listed in Table 1. As shown in Table 2, the mixture for the thermomechanical pulp contained equal amounts of the three lightest colored woods.

Kraft Pulping

Based on the results of preliminary kraft pulping studies made with mixtures of all 50 species combined in three different specific gravity distributions (AID Report No. 1), the following conditions were chosen to make pilot-scale digestions:

(a) 16.0 percent active alkali.

(b) 25 percent sulfidity.

(c) 4-to-1 water-to-wood ratio.

(d) 90 minutes to raise the temperature to 170° C.

(e) 90 minutes at 170° C.

Chips with a dry weight of 140 pounds were used in each pilot-scale digestion. At the end of cooking, the digester was blown. The resulting pulp was washed, screened through a 0.012-inch slotted flat screen, and wet lapped. The composite pulps had a Kappa number of 22.8.

Thermomechanical Pulping

The mixture of light-colored chips was converted into thermomechanical pulp at the pilot plant of C. E. Bauer, Springfield, Ohio. The chip mixture was given an initial 2-minute steaming at 30 p.s.i.g. and then fiberized to about 400 Canadian Standard freeness in a

418-pressurized refiner. This high-freeness pulp was returned to the Forest Products Laboratory (FPL) in order for us to have better control and more flexibility in subsequent refining stages to develop optimum properties of this pulp for use in various papers.

Preliminary atmospheric refining trials made with this high-freeness pulp in a 36-inch disk mill indicated that it was necessary to lower the freeness to about 125 Canadian Standard freeness in order to develop optimum properties. Consequently, the larger batches of pulp for the paper machine trials were refined to this freeness.

Bleaching

The Philippine hardwood kraft pulp was bleached to a brightness of 86.7 percent in a five-stage bleach consisting of chlorination, extraction, chlorine dioxide, extraction, and chlorine dioxide. The conditions are given in Table 3.

The thermomechanical pulp made from the three-species mixtures was too low in brightness for use in tablet papers, and it was therefore bleached to a brightness of 72.0 percent using a one-stage bleach of hydrogen peroxide. Bleaching conditions are given in Table 4. During the pressurized thermomechanical fiberizing stage, stresses are developed in the fibers. A recommended procedure for relieving these stresses is heating of the pulp slurry above 70° C. and agitating until a constant freeness value is reached. This so-called "latency" was effectively removed from the thermomechanical pulp under the conditions used to make the bleach.

Papermaking

Experimental 12-pound facial tissue, 14-pound toilet tissue, and 30-pound toweling were made from furnishes containing (a) 80 percent Philippine hardwood kraft pulp and (b) 40 percent of this kraft pulp and 40 percent Philippine hardwood thermomechanical pulp. In addition, toweling was made from 30 percent Philippine hardwood kraft, 60 percent thermomechanical pulp, and 10 percent long-fiber kraft pulp. The remainder of each furnish consisted of a commercial long-fiber kraft pulp. The facial tissues were dry creped at 95 percent solids or above with 0.05 percent of a polyamide resin added to the furnish for better adhesion at the creping dryer. The toilet tissue was wet creped at about 53 percent solids and the toweling at 50 to 60 percent. The toweling furnishes had 0.25 percent of a wet strength resin added continuously. The pH of all furnishes was adjusted to 7.0 with acid because of the high alkalinity of Madison city water. The all-kraft furnish was jordan refined to a Canadian Standard freeness of about 540 milliliters. Those furnishes containing thermomechanical pulp were already at a low freeness and thus received no processing.

For comparison purposes, tissue and toweling were also made on the experimental paper machine using a furnish of 80 percent hardwood bleached kraft pulp and 20 percent of the long-fiber kraft pulp both obtained from North American manufacturers. This furnish was also jordan refined to about 540 milliliters. The commercial kraft pulps were received in air-dried lap form. The Philippine hardwood kraft pulp used in these experiments consisted of equal parts of never-dried pulp and pulp dried to about 80 percent solids content.

## Results

### Pulp Properties

The handsheet properties of both the unbleached and bleached Philippine hardwood kraft pulps are given in Table 5. As was found in previous work with other tropical hardwood mixtures, the quality of these pulps was better than that of kraft pulps made from North American hardwood mixtures. Bleaching of the Philippine hardwood kraft pulp with CEDED increased the tearing resistance about 10 percent while maintaining the bursting and tensile strengths. The strength properties of the commercial western Canadian softwood bleached kraft pulp and the commercial southern U.S. hardwood bleached kraft pulp are given in Table 6, and those of the bleached thermomechanical pulp are given in Table 7.

### Tissue and Toweling Papers

Results for the various experimental papers are presented in Table 8. Samples of the papers are included in the report. Properties of "weigh sheets" taken directly from a commercial paper machine prior to converting are also included in the table.

A soft, absorbent facial tissue was made with 80 percent Philippine hardwood kraft pulp. This tissue was somewhat better in these characteristics than the reference tissue made with commercial hardwood kraft pulp, which in turn was better than the "weigh sheets." Its cross machine tensile strength was slightly lower than the experimental reference but better than that of the "weigh sheets."

Replacing half of the Philippine hardwood kraft pulp with the Philippine hardwood thermomechanical pulp resulted in a less soft and absorbent facial tissue but still softer than the "weigh sheets." It had good strength properties.

Good-quality toilet tissues were also made with the Philippine hardwoods. The 80-20 Philippine hardwood kraft and long-fiber sheet had the best softness, and its absorbency was comparable to the experimental reference. While its strength was slightly lower than the experimental reference, it was somewhat stronger than the "weigh sheet." Adding thermomechanical pulp lowered the softness and absorbency, but the strength was better.

The toweling paper made with 80 percent Philippine hardwood kraft pulp had more than adequate strength, but it was not as soft or as absorbent as the experimental control. With less processing, better softness and absorbency undoubtedly could be obtained at a sacrifice of some of the excess strength. An improvement in both these characteristics was found to take place when half of the kraft pulp was replaced with thermomechanical pulp. However, increasing the amount of thermomechanical pulp in the furnish from 40 to 60 percent had a slight, adverse effect on both softness and absorbency, but not on strength. All of the experimental toweling papers easily met the requirements specified by the Government in Federal Specification UU-T-591d for paper towels.

## Conclusions

Acceptable sanitary tissue and toweling papers can be made using as much as 80 to 90 percent Philippine hardwoods. Thermomechanical pulp can be used in place of part of the kraft with no significant changes in the quality of the papers.

Table 1.--Names and Specific Gravities of the Philippine Hardwood Mixture Used to Make Kraft Pulp

| Common name | Botanical name | Specific gravity |
|---|---|---|
| Tangisang-bayauak | Ficus variegata | 0.236 |
| Binuang | Octomeles sumatrana | .242 |
| Kapok | Ceiba pentandra | .244 |
| Balilang-uak | Meliosma macrophylla | .260 |
| Kaitana | Zanthoxylum rhetsa | .296 |
| Ilang-ilang | Cananga odorata | .308 |
| Anabiong | Trema orientalis | .319 |
| Hamindang | Macaranga bicolor | .324 |
| Balanti | Homalanthus populneus | .356 |
| Mayapis | Shorea squamata | .366 |
| Matang-arau | Melicope triphylla | .381 |
| Malasantol | Sandoricum vidalii | .394 |
| White lauan | Pentacme contorta | .401 |
| Tulo | Alphitonia philippinensis | .422 |
| Tangile | Shorea polysperma | .429 |
| Pahutan | Mangifera altissima | .435 |
| Apanit | Mastixia philippinensis | .447 |
| Lago | Pygeum vulgare | .451 |
| Antipolo | Artocarpus blancoi | .469 |
| Bagtikan | Parashorea plicata | .478 |
| Sakat | Terminalia nitens | .485 |
| Red Lauan | Shorea negrosensis | .510 |
| Itangan | Weinmannia luzoniensis | .526 |
| Piling-liitan | Canarium luzonicum | .549 |
| Palosapis | Anisoptera thurifera | .554 |
| Lomarau | Swintonia foxworthyi | .559 |
| Malabetis | Madhuca oblongifolia | .560 |
| Dangkalan | Calophyllum obliquinervium | .568 |
| Panau | Dipterocarpus gracilis | .576 |
| Katmon | Dillenia philippinensis | .592 |
| Batitinan | Lagerstroemia piriformis | .597 |
| Katong-lakihan | Amoora macrophylla | .608 |
| Narig | Vatica mangachapoi | .618 |
| Miau | Dysoxylum euphlebium | .623 |
| Apitong | Dipterocarpus grandiflorus | .623 |

(Sheet 1 of 2)

Table 1.--Names and Specific Gravities of the Philippine Hardwood Mixture Used to Make Kraft Pulp--Con.

| Common name | Botanical name | Specific gravity |
|---|---|---|
| Bok-bok | Xanthophyllum excelsum | 0.639 |
| Kamatog | Erythrophloeum densiflorum | .650 |
| Dalingdingan | Hopea foxworthyi | .667 |
| Katilma | Diospyros nitida | .679 |
| Yakal | Shorea astylosa | .718 |
| Kamagong | Diospyros philippinensis | .720 |
| Katong-Matsin | Chisocheton pentandrus | .725 |
| Manaring | Lithocarpus soleriana | .736 |
| Ipil-ipil | Leucaena leucocephala | .737 |
| Bolong-eta | Diospyros pilosanthera | .743 |
| Makaasim | Syzygium nitidum | .778 |
| Alupag-amo | Litchi philippinensis | .793 |

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Table 2.--Names and Specific Gravities of the Philippine Hardwood Mixture[1] Used to Make Thermomechanical Pulp

| Common name | Botanical name | Specific gravity |
|---|---|---|
| Rarang | Erythrina subumbrans | 0.264 |
| Gubas | Endospermum peltatum | .316 |
| Dita | Alstonia scholaris | .316 |

[1]Mixture contained equal amounts (dry-weight basis) of each species.

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Table 3.--Bleaching of Philippine Hardwood Kraft Pulp Used in Tissue and Toweling Papers

| Stage | Chlorination | Extraction | Dioxide | Extraction | Dioxide |
|---|---|---|---|---|---|
| Chemical: | | | | | |
| Formula | $Cl_2$ | NaOH | $ClO_2$ | NaOH | $ClO_2$ |
| Amount applied...pct | 5.5 | 2.0 | 0.76 | 1.0 | 0.38 |
| Temperature.....°C | 25 | 71 | 68 | 50 | 70 |
| Consistence.....pct | 1.9 | 10.6 | 4.0 | 10.9 | 3.6 |
| Duration.....min | 60 | 60 | 120 | 60 | 180 |
| pH: | | | | | |
| Initial..... | 2.8 | 11.4 | -- | 11.8 | -- |
| Final..... | 2.7 | 11.3 | 6.7 | 11.6 | 6.5 |
| Brightness.....pct | -- | -- | -- | -- | 86.7 |

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Table 4.--Bleaching of Philippine Hardwood Thermomechanical Pulp Used in Tissue and Toweling Papers

| | |
|---|---|
| Chemical: | |
| Formula | $H_2O_2$ |
| Amount applied, pct | 0.96 |
| Amount consumed, pct | 0.87 |
| Temperature, °C | 73 |
| Consistence, pct | 9.6 |
| Duration, min | 300 |
| pH: | |
| Initial | 10.3 |
| Final | 9.3 |
| Brightness: | |
| Orginal, pct | 54.7 |
| Final, pct | 72.0 |

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Table 5.--Handsheet Properties of Unbleached and Bleached Philippine Hardwood Kraft Pulps Used in Tissue and Toweling Papers

| Properties | Unbleached | | | | Bleached | | | |
|---|---|---|---|---|---|---|---|---|
| Beating time.....min | 0 | 14 | 27 | 42 | 0 | 13 | 29 | 37 |
| Freeness (CSF).....ml | 615 | 505 | 390 | 240 | 580 | 480 | 335 | 230 |
| Burst factor..... | 32 | 54 | 70 | 82 | 28 | 46 | 65 | 72 |
| Tear factor..... | 116 | 121 | 115 | 108 | 130 | 132 | 129 | 125 |
| Breaking length.....km | 6.8 | 9.7 | 10.6 | 12.3 | 4.9 | 7.2 | 9.6 | 10.2 |
| Apparent density....g/cm$^3$ | 0.56 | 0.62 | 0.66 | 0.70 | 0.62 | 0.64 | 0.70 | 0.70 |
| Brightness.....pct | 25.1 | -- | -- | -- | 86.7 | -- | -- | -- |

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Table 6.--Handsheet properties of commercial bleached kraft pulps used in tissue and toweling papers

| Properties | Softwoods--western Canada | | | | Hardwoods--southern U.S. | | | |
|---|---|---|---|---|---|---|---|---|
| Beating time.....min | 0 | 22 | 43 | 64 | 0 | 17 | 33 | 43 |
| Freeness (CSF).....ml | 665 | 530 | 415 | 275 | 680 | 570 | 375 | 245 |
| Burst factor..... | 24 | 75 | 96 | 104 | 11 | 32 | 54 | 57 |
| Tear factor..... | 248 | 114 | 110 | 108 | 100 | 117 | 112 | 106 |
| Breaking length.....km | 4.1 | 9.4 | 11.3 | 12.6 | 3.0 | 6.1 | 8.0 | 8.6 |
| Apparent density...g/cm$^3$ | 0.61 | 0.67 | 0.72 | 0.73 | 0.55 | 0.63 | 0.68 | 0.69 |
| Brightness.....pct | 86.5 | -- | -- | -- | 89.4 | -- | -- | -- |

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Table 7.--Handsheet properties of bleached Philippine Hardwood Thermomechanical Pulp Used in Tissue and Toweling Papers

| | |
|---|---|
| Freeness (CSF).....ml: | 170 |
| Burst factor.....: | 9.8 |
| Tear factor.....: | 40.3 |
| Breaking length.....km: | 2.5 |
| Apparent density.....$g/cm^3$: | 0.44 |
| Brightness.....pct: | 71.4 |
| Scattering coefficient.....: | 630 |
| Opacity.....pct: | 88.0 |

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Table 8.--Properties of Tissue and Toweling Papers

| Machine run No. | Bleached pulp furnish: Philippine hardwood: Kraft | Philippine hardwood: TMP[3] | Commercial kraft: Hardwood | Commercial kraft: Softwood | Stuff-free-ness (CS) | Weight: Square meter | Weight: 24x36, 500 | Thickness[2] | Bursting strength | Tensile strength: Dry: Machine direction | Tensile strength: Dry: Cross direction | Tensile strength: Wet: Machine direction | Tensile strength: Wet: Cross direction | Stretch: Machine direction | Stretch: Cross direction | Water absorbency (0.1 $cm^3$) | Softness: Machine direction | Softness: Cross direction | Softness: Overall | Brightness (Elrepho) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pct | Pct | Pct | Pct | Ml | G | Lb | Mils | Pts | P.i.w. | P.i.w. | P.i.w. | P.i.w. | Pct | Pct | S | | | | Pct |
| NOMINAL 12-POUND DRY-CREPED FACIAL TISSUE[4] | | | | | | | | | | | | | | | | | | | | |
| Commercial "weigh sheet"[5] | | | | | | 17.6 | 10.8 | 2.8 | 1.18 | 1.01 | 0.31 | -- | -- | 20.8 | 4.9 | -- | 400 | 144 | 240 | 84.2 |
| [6]7127 | -- | -- | 80 | 20 | 550 | 19.0 | 11.7 | 3.3 | 1.59 | .78 | .53 | 0.09 | 0.07 | 25.2 | 2.4 | 69.4 | 1,686 | 170 | 535 | 84.8 |
| [7]7129 | 80 | -- | -- | 20 | 540 | 18.4 | 11.3 | 3.1 | 1.03 | .42 | .44 | .11 | .09 | 21.4 | 2.5 | 46.4 | 5,649 | 248 | 1,184 | 83.7 |
| [7]7132 | 40 | 40 | -- | 20 | 460 | 22.1 | 13.6 | 3.5 | 2.18 | 1.03 | .83 | .19 | .19 | 27.6 | 2.8 | 65.2 | 1,346 | 130 | 418 | 73.8 |
| NOMINAL 14-POUND WET-CREPED TOILET TISSUE | | | | | | | | | | | | | | | | | | | | |
| Commercial "weigh sheet"[5] | | | | | | 21.3 | 13.1 | 3.1 | .85 | .67 | .33 | -- | -- | 18.8 | 3.3 | -- | 376 | 100 | 195 | 76.8 |
| [6]7125 | -- | -- | 80 | 20 | 520 | 21.2 | 13.0 | 3.3 | 3.45 | 1.53 | 1.05 | -- | -- | 7.4 | 2.0 | 30.4 | 434 | 213 | 304 | 87.6 |
| [7]7130 | 80 | -- | -- | 20 | 540 | 21.0 | 12.9 | 3.1 | 2.66 | 1.15 | 1.00 | -- | -- | 6.0 | 2.6 | 31.1 | 391 | 451 | 420 | 83.2 |
| [7]7133 | 40 | 40 | -- | 20 | 460 | 23.8 | 14.6 | 4.1 | 3.08 | 1.66 | 1.26 | -- | -- | 10.2 | 2.0 | 49.8 | 374 | 189 | 266 | 74.2 |
| NOMINAL 30-POUND WET-CREPED TOWELING PAPER[8] | | | | | | | | | | | | | | | | | | | | |
| Commercial "weigh sheet"[5] | | | | | | 55.0 | 33.8 | 7.4 | 4.90 | 3.40 | 2.40 | .97 | .58 | 9.9 | 3.2 | 10.0 | 26 | 12 | 18 | -- |
| [6]7126 | -- | -- | 80 | 20 | 520 | 48.9 | 30.0 | 6.5 | 6.60 | 6.42 | 3.58 | -- | -- | 10.4 | -- | 12.6 | 102 | 20 | 45 | 87.8 |
| [7]7131 | 80 | -- | -- | 20 | 540 | 49.4 | 30.4 | 5.9 | 12.80 | 8.60 | 7.50 | 2.20 | 1.70 | 7.9 | -- | 33.8 | 39 | 17 | 26 | -- |
| [7]7134 | 40 | 40 | -- | 20 | 460 | 48.9 | 30.0 | 6.2 | 8.80 | 6.40 | 5.20 | 1.70 | 1.10 | 7.4 | -- | 18.4 | 47 | 23 | 33 | 72.8 |
| [7]7135 | 30 | 60 | -- | 10 | 370 | 52.6 | 32.3 | 8.1 | 8.00 | 7.76 | 6.30 | 2.07 | 1.45 | 8.4 | 2.3 | 24.1 | 40 | 8 | 18 | 70.2 |

[1]Tested according to TAPPI Standard Methods.

[2]Crepe not removed.

[3]Thermomechanical pulp.

[4]0.05 percent polyamide resin added to furnish for better adhesion to creping dryer.

[5]Supplied by U.S. manufacturer from commercial runs for converting to the consumer grade.

[6]Control.

[7]Furnishes received no processing; others refined with jordan on the machine.

[8]0.25 percent wet-strength resin added to furnish, except run 7126.

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