PULPING AND PAPERMAKING EXPERIMENTS ON COLOMBIAN WOODS

No. 2117

June 1958

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

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

PULPING AND PAPERMAKING EXPERIMENTS ON COLOMBIAN WOODS[1]

By

G. H. CHIDESTER, Chief, Division of Pulp and Paper
and
E. R. SCHAFER, Chemical Engineer

Forest Products Laboratory,[2] Forest Service
U. S. Department of Agriculture

Summary

Thirty-one samples of broad-leaved species of wood were pulped by the groundwood, neutral sulfite semichemical, cold soda, and sulfate methods, and used to make newsprint, wrapping, and writing papers, insulating board, and hardboard.

The woods were divided into four mixtures for the experiments. Mixture A consisted of six woods selected for making groundwood pulp for the newsprint papermaking experiments. For mixture B, the 25 woods not included in mixture A were pulped by the neutral sulfite semichemical and cold soda processes. The semichemical pulp was used in the newsprint papermaking experiments. Mixture C, consisting of all woods, was pulped by: (1) the sulfate process, for use in wrapping and writing papers; (2) the neutral sulfite semichemical process, for use in writing paper; and (3) the Asplund process, for use in hardboard and insulating board. For mixture D, nine woods were selected to make cold soda pulp for newsprint papermaking experiments.

The woods in each mixture were proportioned according to their natural occurrence in the Colombian forests, as determined by a forest survey.

The different kinds of paper were made entirely from the Colombian hardwood pulps (unbleached or bleached) or from blends of the hardwood pulps with commercial North American sulfate pulps.

Wrapping paper was made from blends of the hardwood sulfate pulp, prepared from mixture C, and a commercial northern pine sulfate pulp. In the several papers, the hardwood pulp comprised 100, 85, 75, and 60 percent of the fiber furnish. The paper made 100 percent of hardwood pulp had slightly lower strength properties than the reference standard. The addition of 15 and 25

[1]This work was done in cooperation with the Instituto de Fomento Industrial, Bogota, Colombia.

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

percent of long-fiber sulfate pulp increased the tearing resistance to values comparable to the standard. When the long-fiber portion was increased to 40 percent, wrapping paper with acceptable tearing resistance and bursting strength for a grade B paper was produced.

A linerboard was made from 85 percent of the Colombian hardwood sulfate pulp (mixture C) and 15 percent of northern pine sulfate pulp. The board had good formation, and its bursting strength was equivalent to that required for a high-quality test liner. Results of the ring-crush test, which is a measure of the stiffness of the board, also were good, but the board was a little deficient in tearing resistance.

All of the pulps used in the newsprint papers were too dark colored to be used in their natural state, so they were semibleached. With adequate processing treatment, a paper consisting of 50 percent of Colombian hardwood groundwood pulp made from mixture A, 30 percent of neutral sulfite semichemical pulp from mixture B, and 20 percent of long-fiber kraft had better strength properties than the average of several samples of North American newsprint. The opacity of this paper, however, was slightly lower than that of the American papers. With the hope of improving its opacity, the groundwood content was increased to 60 percent and the long-fiber component was reduced to 10 percent. The strength properties of the resulting paper, which consisted 90 percent of the Colombian hardwood pulps, were practically equal to those of the commercial papers, and had good brightness. Nevertheless, the opacity value, although improved, was still about 4 points lower than the average for commercial newsprint paper.

Newsprint papers containing cold soda pulp made from mixture D were lower in strength than papers containing an equal amount (30 percent) of semichemical pulp, but they had better opacity. When the proportion of cold soda pulp was increased to 50 percent and that of groundwood pulp lowered to 30 percent, the strength values of the papers were comparable to those of the commercial standard and their opacity was lowered only a little.

A fully bleached sulfate pulp and a neutral sulfite semichemical pulp made from mixture C were used to produce bond-type writing papers. Each paper consisted entirely of one of these kinds of pulp.

A paper made from unjordaned sulfate pulp met the bursting strength requirements of a No. 1 bond paper. A paper made from the jordaned pulp was higher in bursting strength but lower in tearing strength than that made from unjordaned sulfate pulp.

A paper made from unjordaned semichemical pulp was lower in strength than the paper made from the sulfate pulp and, though improved in bursting strength by jordaning the stock, was still below No. 1 bond paper. The addition of a small amount of long-fiber pulp would undoubtedly have produced paper with acceptable quality.

The woods in mixture C were fiberized in a laboratory-model Asplund Defibrator, then refined in a disk-type mill and used to make hardboard and insulating board. The hardboard stock consisted entirely of Asplund pulp. The insulating board stock consisted of Asplund pulp and highly refined neutral sulfite semichemical pulp, also prepared from mixture C and added as a binder. Though the insulating board made did not meet Federal specifications for sheathing grades, the results show that board of building grade can be made. Hardboard comparable in quality to many types of untreated board manufactured in the United States was made from the Asplund pulp.

Introduction

The woods used in this research were cut from two types of forests in the valley of the Magdalena River in Colombia. The species in these forests are so intermixed that an economical utilization of them for papermaking virtually requires that they be used without segregation or, if selection is necessary, that they be grouped into mixtures as large as possible.

In the work described here, 31 samples of broad-leaved species of wood were pulped in a single mixture, and in 3 selected mixtures of 6, 9, and 25 species each. Groundwood, cold soda, neutral sulfite semichemical, and sulfate pulps were made and used in varying amounts to make newsprint, wrapping, and writing papers, linerboard, insulating board, and hardboard.

In general, the amount of each wood selected for a mixture was proportioned according to the volume of its occurrence in the two forest types combined. Mixture A consisted of six woods selected for making groundwood pulp to be used in the newsprint papermaking experiments. The selection was based on the results of exploratory grinding tests on 16 of the lighter colored woods. For mixture B, the 25 woods not included in mixture A were chipped and the mixture was used for neutral sulfite semichemical and cold soda pulping experiments. The semichemical pulp was used in the newsprint papermaking experiments, but the cold soda pulp was too weak to have any use possibilities.

Mixture C consisted of proportionate amounts of all woods. Pulps were prepared by: (1) the sulfate process, for use in wrapping and writing papers; (2) the neutral sulfite semichemical process, for use in writing paper; and (3) the Asplund process, for use in hardboard and insulating board. For mixture D, chips from 9 selected woods were prepared for cold soda pulping after it developed that mixture B was not suitable for pulping by this process. The pulp was used in the newsprint experiments.

The four mixtures, showing tree numbers, common names and genus names, are made up of:

Mixture A

Tree No.	Common Name	Genera	Tree No.	Common Name	Genera
1	Jobo	Spondias	18	Fresno	Tapirira
4	Guamo blanco	Inga	24	Juana mestiza	Pterocarpus
17	Escobillo	Xylopia	27	Ceiba de leche	Hura

Mixture B

Tree No.	Common Name	Genera	Tree No.	Common Name	Genera
2	Coco mono	Lecythis	16	Quebracho	Heisteria
3	Latigo	Swartzia	19	Aceituno	Humiria
5	Arenillo	Catostemma	20	Leche perro	Pseudolmedia
6	Sangre toro	Virola	21	Soquete	Iryanthera
7	Petrillo	Couma	22	Cartengo	Pseudobombax
8	Coco cristal	Eschweilera	23	Palanco	Malmea
9	Sapan	Bowdichia	25	Lechero	Sapium
10	Carbonera	Abarema	26	Antorchio	Coccoloba
11	Anime	Protium	28	Caracoli	Anacardium
12	Caimo	Pouteria	29	Malagano	Luehea
13	Tamarindo	Dialium	30	Guaimaro	Brosimum
14	Cana bravo	Crudia	31	Guamo rosario	Carapa
15	Sahino	Goupia			

Mixture C

All 31 woods

Mixture D

Tree No.	Common Name	Genera	Tree No.	Common Name	Genera
1	Jobo	Spondias	17	Escobillo	Xylopia
4	Guamo blanco	Inga	18	Fresno	Tapirira
7	Perillo	Couma	24	Juana mestiza	Pterocarpus
11	Anime	Protium	27	Ceiba de leche	Hura
			31	Guamo rosario	Carapa

Description of Wood

The kinds of wood and the proportions used in the mixtures are given in table 1. The listing is in the order of relative availability. The specific gravity of the sample of each species is also given. Nearly all the denser woods are among the more abundant species. The weighted average specific gravity values of the four mixtures were: A, 0.488; B, 0.679; C, 0.660; and D, 0.485.

The fiber lengths of the 31 woods given in table 2 ranged from a minimum average of 0.854 millimeter for antorchio (Coccoloba sp.) to a maximum of 2.311 millimeters for cartageno (Pseudobombax septenatum). Vessel-member lengths (table 3) ranged from a minimum of 0.286 millimeter in juana mestiza (Pterocarpus sp.) to a maximum of 1.844 in aceituno (Humiria sp.). The majority of the woods had fiber length averages exceeding 1.04 millimeters, which is average for aspen (Populus tremuloides) fiber.

Tension wood and compression failures commonly associated with it were found in more than a third of the woods; in several, tension wood was quite pronounced. This type of abnormal structure causes serious defects in the quality of hardwood lumber and possibly affects the quality of the pulp (9).[2]

Groundwood Pulping

Preliminary groundwood pulping tests were made individually on 16 of the woods that appeared to be the lightest in color. The lower density woods would be expected to produce groundwood pulps of better strength than those from the higher density hardwoods. Many of the woods selected on the basis of color, however, were quite dense, and relatively few were both light colored and of low density.

On the basis of the preliminary tests, six woods were selected for making a quantity of groundwood for the papermaking experiments. Table 1 gives the species and their proportions in this mixture (mixture A). Although some of these woods were apparently stained, they were included because in the unstained condition they would probably be bright enough to be satisfactory.

These 6 woods represent almost 13 percent of the volume represented by the 31 species. Some additional light-colored woods of low density could probably be added to this mixture to increase the amount of wood available for groundwood without adversely affecting the groundwood pulp properties.

Data on grinding of the mixture and the properties of the groundwood pulp are given in table 4. The grinding rate was high and the energy consumption was normal or slightly below. The pulp was short-fibered and low in all strength properties, as well as in brightness, when compared to North American newsprint-grade groundwood. The pulp was bleached before it was used in the papermaking experiments.

---

[2] Underlined numbers in parentheses refer to literature cited at the end of this report.

Neutral Sulfite Semichemical Pulping

In the neutral sulfite semichemical process, the chips are digested with a solution of sodium sulfite and sodium carbonate or bicarbonate. The digestion is followed by a mechanical treatment of the softened material to complete the separation of the fibers. This process, when applied to the broad-leaved species of the temperate zone, has furnished high-yield pulps stronger than can be obtained by using the other common methods of pulping. The brightness of the pulp depends largely on the color of the wood. Light-colored woods give comparatively light-colored pulps, for example.

Semichemical pulping experiments on the Colombian woods were made with mixtures B and C. Digestions of mixture B were planned for pulp to be used in making newsprint paper. Digestions with mixture C were planned for a writing-paper grade of pulp. In the experiments, the digestions were intended to produce pulps in the ranges of yield obtained for comparable grades of pulp from the North American hardwoods.

The results of a series of experiments showed that, for a given yield, both mixtures consumed the same amount of sodium sulfite. The quantity consumed ranged from normal to slightly greater than normal in comparison with representative North American species. The lignin content values of the pulp were high compared with those for pulps digested to the same yield from the broad-leaved species of the northern temperate zone. Pulps from mixture C, for example, which were digested to a yield range of 62 to 72 percent, had lignin content values of between 15 and 18 percent. If this mixture had been digested to a lignin content of 10 percent, which is the preferred maximum for efficient bleaching, the yield would probably have been well below 60 percent, compared with 65 to 72 percent for most northern species.

Pulp No. 5596N (mixture B, table 5) was made for use in the newsprint-paper furnishes. Because of its low brightness, it had to be semibleached for this purpose. Pulp No. 5598N (mixture C)was made for full bleaching and use in writing-paper (bond) furnishes. The cooked chips required more energy for fiberizing than the North American hardwoods. Two passes through the Bauer mill were necessary for digestion 5596N, which was cooked to a yield of 73.5 percent (table 6). The tearing resistance of these pulps was higher than usually obtained for neutral sulfite semichemical pulps. On the other hand, the folding endurance was relatively low, the bursting strength was not impressive, and the breaking length was only fair in comparison with those for pulps from northern hardwoods.

Cold Soda Pulping

Pulps made from North American hardwoods by a high-yield caustic soda process developed at the Forest Products Laboratory have shown promise for use in corrugating boards and such printing papers as newsprint. Cold soda pulps produced in a yield range of 88 to 92 percent have opacity and softness characteristics that make them more suitable for use in newsprint. These hardwood cold soda pulps are stronger than softwood groundwood pulps and have been demonstrated experimentally to be suitable as partial replacements for both the long-fibered chemical and the groundwood pulp components used in newsprint furnishes (3).

The pulping procedure used in the cold soda process usually consists of steeping wood chips in a solution of sodium hydroxide at room conditions before they are fiberized in a disk attrition mill. Easily penetrated woods can usually be pulped satisfactorily by this process after a 2-hour caustic soda steeping period at atmospheric pressure. More uniform and shorter treatments can be obtained by applying hydrostatic pressure, during the steeping, to the liquor that surrounds the chips (2). The experiments reported here were made with this forced-penetration technique because of the anticipated difficulty in obtaining complete liquor penetration in the chips of the denser Colombian hardwoods.

Two different mixtures of the Colombian hardwood chips were used. Mixture B contained 25 species, as listed in table 1. Mixture D was made up of nine species that were selected on the basis of their color and density. Previous experience has indicated that cold soda pulps made from light-colored hardwoods with low to medium densities are stronger and easier to bleach than those made from dark-colored, dense hardwoods.

Small-scale treatments were made at room temperature and an absolute pressure of about 11 atmospheres on the liquor surrounding the chips. Steeping periods of 1 and 2 hours were used in these trials. The concentrations of caustic soda in the solutions were 40, 60, and 75 grams per liter. The ratio of liquor to wood inside the autoclave during the steeping was approximately 6 to 1.

Some of the chips from each trial were examined for extent of liquor penetration after the caustic treatment. All of the chips examined appeared to be completely penetrated, and sank when placed in water. Many of the chips in mixture B remained hard after the caustic soaking, even though they were saturated with the solution. Most of the chips in mixture D were well softened by the treatments.

A larger quantity of cold soda pulp, for use in bleaching and papermaking trials, was prepared from mixture D by treating 120 pounds of chips (ovendry weight basis). During a 2-hour room-temperature treatment in the digester, a gage pressure of 150 pounds per square inch was maintained by circulating the liquor through the digester from bottom to top with a high-pressure pump for the first hour, and then holding a static pressure head during the second hour. After the liquor was drained from the digester, the chips were soaked in water for about 5 minutes, before they were fiberized, to remove some of the dark-colored reaction products from the chips. The washed chips were fiberized in a commercial-size, 36-inch-diameter, double-rotating disk mill. A single pass through the mill produced a pulp with a freeness of 435 cubic centimeters (Canadian Standard) and consumed 22.2 horsepower-days of energy per ton of moisture-free pulp, which is about the same as that required to fiberize North American hardwoods in this process.

The larger scale treatment of mixture D (treatment No. 4166, table 7) consumed 0.5 percent more chemical and produced 2 percent less pulp than a similar treatment made in the smaller autoclave. These results were probably caused in part by the increased activity of the caustic soda solution as it was circulated over the surface of the chips in the digester. Although the digester pulp was lower in yield and would be expected to be darker than the autoclave pulp, its actual brightness was slightly higher (0.7 percent). This improvement in brightness can probably be attributed to the quick washing given the chips in the digester before they were fiberized.

The strength properties of the cold soda pulps were somewhat below those of aspen cold soda pulp (treatment No. 4134, table 7). The pulps made from mixture D were stronger and brighter than those made from mixture B. The pulps made from treatments at room temperature on mixture B were too weak to have any use possibilities.

All of the cold soda pulps made from these mixtures were very bulky in comparison with aspen cold soda pulp, and therefore they would be expected to increase the porosity of newsprint paper. The variations in treating conditions had little effect on the bulk of the pulp. The densities of the sheets fell in a narrow range of 0.34 to 0.39 gram per cubic centimeter.

This work has shown that mixture D, which contains nine of the Colombian hardwoods, can be pulped satisfactorily by the cold soda process. The yield and quality of the pulps were below those of cold soda pulps made from such North American hardwoods as aspen; also, a greater amount of caustic soda was required. The strength values of unbleached pulp were high enough to make them as acceptable as groundwood pulp for newsprint furnishes. The brightness value was in a medium range and would be expected to increase to a newsprint level with the application of economical amounts of bleaching chemicals.

Sulfate Pulping

Sulfate pulping studies at the Forest Products Laboratory have shown that a wide variety of hardwoods from tropical forests can be pulped satisfactorily by this process. Among these studies were experiments made on a group of four hardwoods found in the forests of Colombia. A good-quality sulfate pulp, prepared from a mixture of these woods, was demonstrated to be suitable for making good-quality printing and wrapping papers (4).

A more comprehensive mixture that contained 31 Colombian hardwoods (mixture C, table 1) was pulped by the sulfate process in the experiments reported here. The chemical analyses of this wood mixture (table 8) indicated that moderate amounts of cooking chemicals would be required to produce bleachable pulps.

The lignin content of 24.1 percent for this mixture was in a range below the average of previously tested tropical hardwoods from other regions, and slightly above the average of North American hardwoods. An above-average pulp yield would be expected because of the comparatively low solubility of this mixture in hot water and 1 percent sodium hydroxide. The apparent amount of hemicelluloses found in these woods, as indicated by either the total pentosan content (13.1 percent) or by the arithmetic difference (16.7 percent) between the holo- and alpha-cellulose contents, was rather low for hardwoods. This might indicate low strength values in the beaten pulp.

Small-scale pulping trials were made with 8 pounds of chips (based on weight of ovendry wood). The pulp fibers were separated in a mixing tank by mechanically stirring the cooked chips after they were washed and removed from the autoclaves.

The conditions for the sulfate digestions were maintained throughout the series of tests except for variations in the chemical-to-wood ratio, which necessarily changed the concentration of the cooking liquors. The range of chemical-to-wood ratios was within the limits of commercial operation, as were the other conditions. The 25.5 percent sulfidity of the cooking liquor was close to the average used by sulfate pulp mills in the United States. The sulfate digestions were all made with fresh cooking liquor.

Larger scale cooks of 140 pounds of ovendry chips were made to provide enough pulp for bleaching and papermaking. At the end of the digestion the chips were broken up into pulp by blowing them from the digester into a tank, as is done commercially.

The results of the small-scale sulfate digestions indicated that bleachable pulps containing low amounts of screening rejects could be made by cooking the mixture with 20 percent of total chemical (based on the ovendry weight of the wood); this is the proportion used for many North American hardwoods. Decreasing the total amount of cooking chemical from 27.5 to 20 percent during the trials increased the yield of screened pulp from 43.6 to 47.0 percent and the amount of screening rejects from 0.5 to 1.1 percent. When this lesser amount of total chemical was used, the permanganate number of the pulp was raised from 13.6 to 18.7. These values are all within the normal limits for bleachable hardwood pulps.

Sulfate pulp made on a larger scale with 20 percent of total chemical (table 9) had a lower permanganate number (17.4), contained fewer screenings (0.3 percent), and gave a higher screened yield (48.3 percent) than the pulp made under the same cooking conditions in the small-scale equipment.

The improved pulping obtained in the larger digester was consistent with previous experience, and might be partly due to the blowing operation used to separate the fibers at the end of the digestion.

The strength properties of the pulp compared favorably with those of some of the strongest sulfate pulps made from North American hardwoods (table 9). At the same pulp freeness values, the bursting strength of the Colombian pulp was almost equal to that of the best sulfate pulps made from North American hardwoods, while its tensile strength and folding endurance were about 10 to 20 percent less. The tearing resistance of the Colombian pulp was exceptionally high for hardwood pulp. It was one-third or more above the usual range of hardwood sulfate pulps. The density values of the handsheets made from this pulp were about 20 percent below those usually obtained from hardwood sulfate pulps in this range of strength properties.

Bleaching

One-Stage Bleach Tests

The response to single-stage hypochlorite bleaching of the groundwood from 6 species (mixture A) and the semichemical pulps from 25 species (mixture B) was about that usually expected for these types of pulps. The brightness increased about 1.8 to 2.2 points for each 1 percent of available chlorine applied. The cold caustic soda pulp from mixture B was much more difficult to bleach than the groundwood or semichemical pulps, as indicated by the lower ratio of brightness increase, 1.5 points for each 1 percent of available chlorine applied. However, the cold caustic soda pulp from 9 selected species (mixture D) was about 9 points brighter than that from mixture B, and was about equal to the groundwood and semichemical pulps in its response to hypochlorite bleaching.

Because of its low initial brightness, the high-yield semichemical pulp from mixture B required the unusually high dosage of 17 percent of available chlorine to bleach it sufficiently for use in newsprint paper. However, 13 percent of available chlorine was adequate for bleaching the low-yield semichemical pulp from mixture C.

Likewise, the brightness of the bleached cold caustic soda pulp from mixture B was about 10 points lower than desired for newsprint, but the pulp from mixture D was brightened satisfactorily with 12 to 15 percent of available chlorine.

Comparison of the strength data of the hypochlorite-bleached pulps with the unbleached pulps showed that bleaching by a one-stage hypochlorite treatment to brightness values up to 60 percent did not decrease pulp strength. In some respects, there was a definite but unimportant increase in some strength properties upon bleaching to this brightness. However, there was a strength loss amounting to 25 to 30 percent when the cold soda pulp from mixture D was bleached to 66 percent brightness.

Multistage Bleach Tests

The sulfate and neutral sulfite semichemical pulps from wood mixture C were bleached by three-stage and four-stage processes. The total chlorine requirement for bleaching the sulfate pulp was estimated from the permanganate number to be about 7 to 7.5 percent. In accordance with mill practice, about 55 to

60 percent of the estimated chlorine requirement was applied as chlorine in the first stage. This chlorination was followed by a treatment with calcium hypochlorite at high alkalinity, because this has been found to produce stronger bleached pulp than when chlorination is followed by the usual caustic soda extraction in a three- or four-stage process. However, the total amount of chlorine required for bleaching is generally higher for this process.

There was essentially no strength loss upon bleaching the sulfate pulp. The values for tearing resistance and folding endurance are within the usual variation between test results. The strength values for the bleached sulfate pulp are in the range of those for bleached sulfate pulps from the better quality North American hardwoods.

The chlorine requirement for bleaching the neutral sulfite semichemical pulp was estimated to about 18 percent, on the basis of 1.2 times the Tingle number. About 75 pounds of the semichemical pulp were bleached in the pilot bleach plant, with about 90 percent of the estimated bleach requirement as chlorine gas in stage 1. After the chlorination and extraction, tests on small samples showed that an unusually high amount of hypochlorite, 8 percent as available chlorine, would be required to bleach the extracted pulp to 80 percent brightness. To obtain more effective bleaching and avoid degradation, this amount of hypochlorite was applied to the larger quantity of pulp in two stages. Though there was evidence that some of the chlorine applied in the first stage of the pilot-plant bleach escaped by passing through the pulp suspension, the high total chlorine consumption of 23.5 percent showed that the semichemical pulp was unusually resistant to bleaching. North American hardwood semichemical pulp of similar yield and Tingle number would not have required so much chlorine for bleaching to this degree of brightness.

As is generally expected in bleaching semichemical pulps, the multistage bleaching increased the bursting strength, folding endurance, and breaking length of the pulp. Although tearing resistance also usually increases a small amount when the pulp is bleached, in this instance it decreased about 17 percent, possibly because of the large amount of hypochlorite required in the bleaching process.

Papermaking

Different grades of bleached and unbleached papers were made with fiber furnishes that consisted either entirely of Colombian hardwood pulps or of blends of the hardwood pulps and commercial North American softwood pulps. The North American pulps were added to improve certain properties, especially tearing resistance, that were lacking in the papers containing only the hardwood pulps.

The pulps were processed in a 50-pound-capacity beater and made into papers on the 13-inch experimental paper machine. The machine was run at a speed of about 70 feet per minute for all grades except the linerboard, which was made at a speed of 15 feet per minute.

Wrapping Paper Series

Wrapping paper runs were made with blends of the hardwood sulfate pulp, prepared from wood mixture C, and a commercial northern pine sulfate pulp. In the several experimental papers made, the hardwood pulp comprised 100, 85, 75, and 60 percent of the fiber furnish.

The long-fiber and the hardwood sulfate pulps were processed separately in the beater, and then blended before the rosin size was added. The hardwood pulp used for the first run (machine run 4517) was brushed only, with no beating to prevent overprocessing. In the other runs, the hardwood pulp was beaten to a freeness of 440 cubic centimeters, Canadian Standard. The long-fiber pulp was beaten to a freeness of 540 cubic centimeters for all runs.

A wrapping paper previously made at the Forest Products Laboratory from a commercial southern pine sulfate pulp was used as the standard of comparison. This standard paper had properties that met Federal specification UU-P-268c for a grade B wrapper.

The paper that contained 100 percent of hardwood pulp (machine run 4521, table 10) had strength values somewhat lower than those of the reference standard. The addition of 15 and 25 percent of the long-fiber sulfate pulp (machine runs 4517, 4518, 4524, and 4525) increased the tearing resistance of the paper to values comparable to the standard. However, no substantial improvement in bursting strength was noted with these small percentages of long fiber. When the long-fiber portion was increased to 40 percent (machine runs 4519 and 4520), a wrapping paper with acceptable tearing resistance and bursting strength for a grade B paper was produced.

Jordaning the various pulp furnishes increased the bursting strength but, as expected, it also reduced the tearing resistance to values somewhat lower than desirable for the grade. This further processing also decreased the freeness values at the paper machine to somewhat lower values than commonly used in the production of grade B paper.

Linerboard

One linerboard run (machine run 4523, table 10) was made with a blend of 85 percent of Colombian hardwood sulfate pulp (mixture C) and 15 percent of northern pine sulfate pulp. The hardwood sulfate pulp was beaten for 45 minutes to a freeness of 440 cubic centimeters (Canadian Standard), and the long-fiber portion was beaten 20 minutes to a freeness of 545 cubic centimeters. The two pulps were blended in the machine chest. The furnish was subjected to a light jordaning. An unsized, 48-pound (per 1,000 square feet) linerboard was made with no machine operating difficulties.

The linerboard had good formation and finish. The Mullen value of approximately 100 points is high--equivalent to that required for a 42-pound test liner. The ring crush, which is a measure of the stiffness of the board, also was higher than the average obtained on three commercial southern kraft linerboards used for comparison; however, the tearing resistance of the board was somewhat lower than that of the kraft linerboards.

Newsprint

The groundwood pulp made from mixture A was low in brightness, so it required bleaching for the newsprint experiments. This pulp was also rather low in strength in comparison with softwood groundwood. Therefore, either semi-bleached neutral sulfite semichemical pulp made from mixture B or semibleached cold soda pulp made from mixture D was substituted for part of the groundwood. These pulps were also substituted for part of the long-fiber chemical pulp. To supply the long fiber needed, a quantity of semibleached southern pine sulfate pulp was beaten separately to a freeness of 490 cubic centimeters (Canadian Standard) to develop bonding strength.

Three newsprint-paper runs were made with the semichemical pulp. The first run (machine run 4526, table 11) consisted 50 percent of hardwood groundwood, 30 percent of neutral sulfite semichemical, and 20 percent of long-fiber kraft. The resultant paper was low in strength in comparison with North American newsprint paper. In the next run, the same furnish was subjected to a jordaning treatment and a paper (machine run 4527) was obtained that had better strength properties than the average of a number of commercial newsprint papers. The opacity of this experimental paper was about 86.3 percent, which is somewhat lower than the average obtained on the commercial newsprint.

For the third run (machine run 4528), the groundwood content was increased to 60 percent to favor opacity; the remainder of the furnish consisted of 30 percent of Colombian hardwood neutral sulfite semichemical pulp and 10 percent of long-fiber sulfate pulp. This furnish, therefore, contained 90 percent of hardwood fibers. The strength properties of the paper were practically equal to the commercial papers. The paper also had good brightness and texture and showed evidence of a desirable open structure, as indicated by low air resistance and high oil absorption. The opacity value was increased, but still it was lower than the commercial newsprint average. An improvement in opacity might be obtained by the addition of a clay filler, but probably at some expense to strength.

Five newsprint-paper runs were made with cold soda pulp in the furnish. The first run (machine run 4622) consisted 50 percent of hardwood groundwood, 30 percent of cold soda, and 20 percent of long-fiber kraft pulp. The paper was low in bursting strength and rather soft. When this furnish was subjected to a jordaning treatment (machine run 4623), a newsprint paper with an average bursting strength nearly equal to that of commercial newsprint resulted. The paper also had good tearing resistance, porosity, and opacity.

In the third run with cold soda pulp (machine run 4624), the furnish contained 90 percent of hardwood pulp (50 percent groundwood, 40 percent cold soda) with long-fiber kraft for the remaining 10 percent. When this furnish was jordaned, the low wet strength of the web prevented continuous operation. Therefore, the furnish was run without jordaning, and a relatively weak sheet resulted.

The papers containing the cold soda pulp had less strength than papers made from equal amounts of semichemical pulp. This could be expected, since the cold soda pulp was weaker than the semichemical pulp. However, the cold soda pulp produced newsprint paper 3 points higher in opacity than the semichemical pulp. Because of this higher opacity, it appeared to be possible to produce a newsprint with satisfactory strength properties by substituting more of the cold soda pulp for the groundwood pulp, which is low in initial strength. The proportion of cold soda pulp was therefore increased to 50 percent and that of the groundwood reduced to 30 percent, with long-fiber kraft for the remainder (machine run 4643). This paper was above the commercial average in strength and was a little less opaque than the other cold soda newsprint papers. The addition of 5 percent of clay to this furnish (machine run 4644) raised the opacity very slightly. This gain probably could not be considered sufficient to balance the decrease in bursting strength, though the bursting strength was equal to the commercial average used for comparison.

It appears that a substantial proportion of the Colombian hardwoods can be used for making neutral sulfite semichemical, cold soda, or groundwood pulp for newsprint purposes.

Sulfate pulp was not included in the newsprint blends, but it is probable that a semibleached sulfate pulp prepared from the wood mixture could be used instead of semichemical pulp, if desired. The strength of the sulfate pulp is a little higher than that of the semichemical pulp.

Bond

The Colombian hardwood bleached sulfate and bleached neutral sulfite semichemical pulps were considered for use in high-quality bond and writing papers. Runs were made with 100 percent of each of these two pulps prepared from mixture C (table 11).

The sulfate pulp was beaten for 55 minutes to a freeness (Canadian Standard) of 415 cubic centimeters. Runs were made without jordaning (machine run 4534) and with moderate jordaning (machine run 4535). Both runs had good formation and finish. The unjordaned sulfate pulp yielded a paper that met the bursting-strength requirements of a No. 1 bond paper. A No. 1 bond paper has a bursting-strength value of at least "a point to the pound" on the basis of a 500-sheet ream of 17- by 22-inch sheets; this is equivalent to 0.37 point per pound per ream of 500 sheets, each 25 by 40 inches, as used in table 17. Jordaning the stock (machine run 4535) increased the bursting strength about 20 percent, with a similar reduction in tearing resistance.

For the runs with the neutral sulfite semichemical pulp, no beating was employed, since the freeness (Canadian Standard) of the pulp was about 400 cubic centimeters. In the first semichemical pulp run (machine run 4529), the stock was not jordaned. The paper was lower in strength than paper made from sulfate pulp at approximately the same freeness. Jordaning the semichemical pulp stock increased the bursting strength to 0.34 point per pound per ream, which was still below the requirements for a No. 1 bond paper. There was practically no difference in strength between papers made with lightly jordaned stock (machine run 4530) and moderately jordaned stock (machine run 4531). The addition of a long-fiber sulfate pulp to the hardwood semichemical pulp would undoubtedly have produced a bond paper with acceptable properties. Lack of enough of the semichemical pulp prevented making an experimental run to prove this probability.

Hardboard and Insulating Board

Stock for use in the hardboard and insulating board experiments was made by defibering chips from the mixture of Colombian woods (mixture C) in a stainless steel, laboratory-model Asplund Defibrator. The defibrated pulps were refined in an 8-inch, single-rotating disk mill. The hardboard pulp was refined with plates with closely spaced radial serrations and a retainer ring, or closed edge. The refining was limited to a mild brushing.

The insulation board pulp was extremely coarse and shivey. From this pulp two stocks, designated as stock A and stock B, were prepared. For stock A, the refining was limited to reducing the coarse particles to a pulplike material. For this purpose, a deep, radially serrated plate with an open edge was used. Stock B was more highly refined, and the plates used were the same ones used to prepare the hardboard stock.

Pulp mats for the preparation of hardboards and insulation boards were formed in an Asplund Defibrator freeness tester. The mats produced were 8-1/2 inches in diameter.

The insulation boards were made partially from either Asplund stock A, or an equal mixture of Asplund stocks A and B; the remainder of the stock in each case was highly refined neutral sulfite semichemical pulp, as shown in table 12. The furnishes of boards Nos. 2030 and 2031 were markedly different from the others. In No. 2031, the amount of defibrated stock was maintained at the 75 to 80 percent level, but the coarseness of the furnish was reduced by mixing equal amounts of stocks A and B. Also, the freeness of the binder stock was higher than that used for boards No. 2026 to 2029. Analysis of the results indicates that boards of acceptable quality would be somewhat high in density (at least 20 pounds per cubic foot). The density of comparable commercial boards is 17 to 18 pounds per cubic foot. It appears questionable whether board No. 2030 would meet sheathing board specifications (8). However, the results indicate conclusively that this board will meet building board specifications.

The relatively high overall density of the mixture of Colombian woods used in these experiments is probably caused, to a considerable extent, by the thick-walled fibers in these woods. Therefore, it is reasonable to expect that insulating board made from these fibers would have a higher density for a given strength than boards made from the lower density woods normally used for this purpose.

The hardboards produced from the mixture of Colombian woods were a pleasant cocoa-brown color and of good appearance. Board No. 2034 (table 13) for all practical purposes met the Federal specifications for class 1, type 1, untreated hardboard. A comparable board, No. 2035, was enhanced by heat treating it for 8 hours at 142° C. Heat treating for 3 hours at 160° C. possibly would have been just as effective (5,7). The yields of pulp were in the range for optimum strength (6). The refining of the pulp approximated the desired defibrator freeness of 40 seconds (1).

Literature Cited

(1) Asplund, A.
1950. Preparation and Characteristics of Fiber Pulp for Hardboard. Northeastern Wood Utilization Council Bull. No. 31, pp. 24-42.

(2) Brown, K. J.
1957. Special Considerations Affecting Improvements in the Cold Soda Pulping Process. Forest Products Laboratory Report No. 2101.

(3) Chidester, G. H., and Brown, K. J.
1954. Use of Bleached Cold Soda Pulps from Certain Mixtures of Latin American Hardwoods in Newsprint. Forest Products Laboratory Report No. 2013.

(4) ________________ and Schafer, E. R.
1954. Pulping of Latin-American Woods. Forest Products Laboratory Report No. 2012.

(5) Lowgren, Uno
1947. Wallboard Manufacture in Sweden According to the Defibration System. West Coast Lumberman, Vol. 74, No. 2, pp. 85-91.

(6) McGovern, J. N., Brown, K. J., and Kraske, W. A.
1949. Experiments on Water and Steam Cooking of Aspen. Tappi, Vol. 32, No. 18, pp. 440-448.

(7) Ogland, N. J.
1948. Norsk Skogind 2, No. 11, pp. 301-305.

(8) Schwartz, S. L.
1952. Insulating Board and Hardboard from Four Common Hardwoods of Northeastern Farm Woodlots. Forest Products Laboratory Report No. D1931.

(9) Watson, A. J.
1956. Pulping Characteristics of Eucalyptus Tension Wood. Proceedings, Australian Pulp and Paper Industry Technical Association, 10:43-59.

Table 1.--Specific gravity and the proportions of each Colombian wood contained in the mixtures used for pulping

Tree Number	Common name of species[1]	Specific gravity[2]	Volumetric proportions of woods in mixtures used for pulping[3]			
			A	B	C	D
			Percent	Percent	Percent	Percent
8	coco cristal	0.748	....	19.64	17.15	....
9	sapan	.795	....	11.05	9.65	....
14	cana bravo	.688	....	9.53	8.34	....
13	tamarindo	.743	....	8.37	7.30	....
19	aceituno	.745	....	5.53	4.83	....
20	leche perro	.650	....	5.22	4.57	....
17	escobillo	.490	34.90	....	4.42	23.20
15	sahino	.707	....	4.47	3.92	....
6	sangre toro	.494	....	4.45	3.89	....
5	arenillo	.555	....	4.26	3.72	....
3	latigo	.752	....	4.03	3.53	....
12	caimo	.737	....	3.95	3.45	....
27	ceiba de leche	.490	23.60	....	2.98	15.63
18	fresno	.522	22.10	....	2.79	14.65
11	anime	.440	....	3.19	2.79	14.65
10	carbonera	.593	....	2.83	2.48	....
16	quebracho	.693	....	2.81	2.45	....
7	perillo	.461	....	2.63	2.30	12.07
21	soquete	.583	....	2.33	2.03	....
4	guamo blanco	.465	16.00	....	2.02	10.60
31	guamo rosario	.438	....	1.51	1.32	6.94
30	guaimaro	.692	....	.88	.77	....
2	coco mono	.598	....	.79	.69	....
28	caracoli	.334	....	.71	.62	....
29	malagano	.383	....	.65	.57	....
26	antorchio	.543	....	.37	.32	....
23	palanco	.725	....	.29	.25	....
24	juana mestiza	.285	1.82	....	.23	1.21
22	cartageno	.277	....	.25	.22	....
25	lechero	.353	....	.23	.20	....
1	jobo	.385	1.58	....	.20	1.05
Specific gravity (weighted average)...			0.488	0.679	0.660	0.485

[1] Listing in order of relative availability.

[2] Basis of ovendry weight and volume when green.

[3] Mixture A was used for groundwood pulping only; mixture B was used for cold soda and neutral sulfite semichemical pulping; mixture C was used in neutral sulfite semichemical, sulfate, and Asplund pulping experiments; mixture D was used for cold soda pulping.

Table 2.--Fiber lengths of 31 Colombian hardwoods

Tree No.	Common name of species	Fiber length: Average	Fiber length: Minimum	Fiber length: Maximum	Standard deviation	Coefficient of variation
		Mm.	Mm.	Mm.	Mm.	Percent
22	Cartengo	2.311	1.350	3.250	0.374	16.1
19	Aceituno	2.216	.925	2.750	.330	14.8
5	Arenillo	1.978	.925	2.750	.394	19.9
15	Sahino	1.926	1.025	2.725	.364	18.8
16	Quebracho	1.694	1.050	2.425	.349	20.6
8	Coco cristal	1.650	.750	2.125	.251	15.2
2	Coco mono	1.618	.900	2.100	.247	15.2
12	Caimo	1.515	.850	2.000	.254	16.7
14	Cana bravo	1.513	.625	2.100	.311	20.5
25	Lechero	1.508	1.000	2.000	.213	14.1
21	Soquete	1.451	.575	2.100	.248	17.0
1	Jobo	1.405	.775	1.875	.270	19.2
9	Sapan	1.392	.675	1.850	.226	16.2
7	Petrillo	1.376	.700	2.025	.261	18.9
23	Palanco	1.358	.450	1.975	.270	19.8
6	Sangre toro	1.350	.525	1.750	.218	16.1
20	Leche perro	1.310	.500	1.875	.216	16.4
29	Malagano	1.299	.650	2.000	.260	20.0
31	Guamo rosario	1.258	.700	1.800	.228	18.1
27	Ceiba de leche	1.223	.575	1.775	.244	19.9
28	Caracoli	1.170	.650	1.750	.203	18.1
13	Tamarindo	1.163	.675	1.625	.155	13.3
3	Latigo	1.155	.700	1.575	.164	14.2
4	Guamo blanco	1.143	.625	1.850	.236	20.6
24	Juana mestiza	1.112	.625	1.500	.176	15.8
10	Carbonera	1.106	.450	1.525	.219	19.8
17	Escobillo	1.062	.500	1.475	.207	19.4
30	Guaimaro	1.027	.525	1.425	.202	19.6
18	Fresno	.963	.575	1.425	.192	19.9
11	Anime	.876	.450	1.225	.186	21.2
26	Antorchio	.854	.300	1.250	.172	20.1

Table 3.--Vessel member length of 31 Colombian hardwoods

Tree No.	Common name of species	Vessel member length: Average	Minimum	Maximum	Standard deviation	Coefficient of variation
		Mm.	Mm.	Mm.	Mm.	Percent
19	Aceituno	1.844	0.877	2.499	0.294	15.9
15	Sahino	1.505	.714	2.142	.253	16.8
16	Quebracho	1.340	.714	1.948	.254	18.9
21	Soquete	1.224	.796	1.612	.180	14.7
6	Sangre toro	1.154	.612	1.683	.189	16.4
25	Lechero	1.005	.571	1.367	.152	15.1
12	Caimo	.931	.612	1.448	.179	19.2
7	Petrillo	.701	.306	1.010	.158	22.5
8	Coco cristal	.696	.352	1.020	.119	17.1
27	Ceiba de leche	.631	.388	.847	.104	16.4
17	Escobillo	.629	.439	.785	.064	10.2
18	Fresno	.625	.326	.918	.113	18.1
1	Jobo	.621	.408	.918	.104	16.7
22	Cartengo	.580	.439	.714	.041	7.1
28	Caracoli	.555	.306	.887	.117	21.0
4	Guamo blanco	.550	.265	.755	.110	20.0
11	Anime	.542	.286	.785	.113	20.8
31	Guamo rosario	.539	.286	.755	.072	13.3
23	Palanco	.526	.388	.663	.056	10.6
20	Leche perro	.503	.296	.694	.088	17.4
2	Coco mono	.485	.235	.683	.094	19.4
26	Antorchio	.484	.224	.694	.098	20.2
14	Cana bravo	.470	.286	.663	.074	15.7
5	Arenillo	.446	.326	.571	.040	8.9
29	Malagano	.434	.316	.622	.050	11.5
10	Carbonera	.432	.204	.622	.078	18.0
9	Sapan	.423	.255	.530	.059	13.9
3	Latigo	.383	.235	.510	.053	13.8
30	Guaimaro	.363	.214	.510	.070	19.2
13	Tamarindo	.290	.153	.408	.037	12.7
24	Juana mestiza	.286	.122	.367	.042	14.6

Table 4.--Groundwood pulping data for a selected mixture[1] of Colombian hardwoods

Pulping data and pulp properties	Values
Grinding data[2] (grinder run No. 1060)	
Wood moisture content (basis, wood plus moisture).percent	56.4
Unit pressure (wood on stone)...............p.s.i. (gage)	47
Power input..............................hp. per sq. ft. of pocket area	125
Energy consumed......................hp.-days per ton of moisture-free wood ground	57
Grinding rate................tons moisture-free wood per sq. ft. of pocket area per 24 hr.	2.20
Pulp properties[3]	
Freeness--Schopper-Riegler...........................cc.	210
Canadian Standard........................cc.	60
Screen analysis	
Retained on 28-mesh...........................percent	2.7
Retained between 28- and 48-mesh...............percent	12.1
Retained between 48- and 100-mesh..............percent	24.2
Retained between 100- and 200-mesh.............percent	20.9
Passing 200-mesh..............................percent	40.1
Properties of pulp test sheets	
Bursting..........................pt. per lb. per rm.[4]	0.08
Tearing...........................gm. per lb. per rm.[4]	.33
Tensile.......................................p.s.i.	584
Breaking length..................................m.	1,053
Density...............................gm. per cc.	0.39
Brightness.................................percent	42.0

[1] Mixture A.

[2] The grindstone used was a natural sandstone and the burr pattern was that obtained with a 10-cut, 1-1/2-inch lead, spiral burr. The stone had been used in other work for 13 hours since it was last burred. The grinding surface was in a fairly dull condition. The grinding temperature was 140° F. and the consistency of the stock in the grinder pit was 4 percent.

[3] Unbleached pulp.

[4] Ream 500 sheets, 25 by 40 inches.

Table 5.--Neutral sulfite semichemical pulping of mixed Colombian hardwoods

Pulping data and pulp characteristics	Digestion No. 5596N	Digestion No. 5598N
Pulping[1]		
Mixture of chips	B	C
Moisture content of chips, percent	18.0	16.0
Liquor charged:		
Volume, gal. per 100 lb. wood[2]	40.0	35.0
Concentration Na_2SO_3, gm. per l.	47.6	80.5
Concentration $NaHCO_3$, gm. per l.	19.7	19.6
Chemical applied:		
Na_2SO_3, percent[2]	15.9	23.5
$NaHCO_3$, percent[2]	6.6	5.7
Maximum cooking temperature, °C.	170	180
Time at maximum temperature[3], hr.	4.25	4.5
Spent liquor:		
Na_2SO_3, gm. per l.	10.2	10.4
pH	7.2	6.4
Pulp		
Yield, percent[2]	73.5	62.2
Lignin content, percent[4]	....	15.2
Brightness (unbleached), percent	....	28.6
Bursting strength[5], pts. per lb. per rm.[6]	0.54	0.55
Tearing resistance[5], gm. per lb. per rm.[6]	.96	1.20
Folding endurance[5], Double folds	12	22
Tensile strength (breaking length)[5], m.	4,950	5,700
Density[5], gm. per cc.	0.49	0.52

[1] Chips steamed lightly for 1/2 hour before adding liquor.

[2] Based on ovendry wood.

[3] Temperature rise--2.5 hours from 70° C. to maximum.

[4] Based on moisture-free pulp.

[5] At 250-milliliter freeness (Canadian Standard) interpolated from freeness versus strength and density curves.

[6] Ream 500 sheets, 25 by 40 inches.

Table 6.--Refining[1] of cooked chips prepared by the neutral sulfite semichemical process for mixed Colombian woods

Refining data	5596N Mixture B: First pass	5596N Mixture B: Second pass	5598N Mixture C
Energy required....hp.-days per ton air-dry pulp	12.6	16.3	16.0
Consistency....percent	10.0	5	10.6
Freeness (Canadian Standard):			
Refiner pit....ml.	550	....	540
Wet machine web....ml.	....	520	520

Digestion No.: 5596N (Mixture B), 5598N (Mixture C)

[1] Refiner was a 36-inch, style 400 Bauer refiner. C-914 plates rotated counter-clockwise.

Table 7.--Cold soda pulping of Colombian hardwood mixture D compared with aspen

Pulping data and pulp characteristics	Digestion No. 4166	Digestion No. 4134
Pulping		
Wood	Mixture D	Aspen
Steeping conditions:[1]		
Time, hr.	2[2]	1
Temperature[3], °C.	26	25
Concentration of NaOH, gm. per l.	75	25
NaOH consumed, percent[4]	8.87	5.02
Pulp[5]		
Yield, percent[4]	88.5	92.1
Freeness (Canadian Standard), ml.	435	350
Bursting strength, pts. per lb. per rm.	0.16	0.41
Tearing resistance, gm. per lb. per rm.	.60	.83
Breaking length, m.	1,684	4,680
Density, gm. per cc.	0.39	0.70
Brightness, percent	37	49

[1] Treatments made under 150 pounds per square inch (gage).

[2] 1 hour under hydraulic pressure; 1 hour under hydrostatic pressure.

[3] Heated by applying steam directly to liquor and chips in the autoclave.

[4] Based on ovendry wood.

[5] Treated chips from digestion No. 4134 were drained free of liquor and stored 2 hours before refining in an 8-inch, single-rotating disk mill. Treated chips from digestion No. 4166 were covered with water, drained immediately, and stored 2 hours before fiberizing in a single pass through a 36-inch, double-disk mill. Pulp tests made on handsheets weighing 55 pounds per ream of 500 sheets, 25 by 40 inches.

Table 8.--Chemical analysis of a mixture of 31 Colombian hardwoods

Constituent	Amount of constituent[1]	
	Colombian hardwoods (mixture C)	United States hardwood pulpwoods[2]
	Percent	Percent
Lignin	24.1	22
Holocellulose	70.9	75
Alpha-cellulose	54.2	47
Pentosans (total)	13.1	19
Solubility in:		
Alcohol benzene	2.06	2.8
Ether	.46	.6
1 percent sodium hydroxide	12.65	14.0
Hot water	2.60	3.5
Ash	.76	.5

[1] Percentages based on ovendry wood.

[2] Average of analyses of 18 woods.

Table 9.--Comparison of properties[1] of sulfate pulp made from Colombian hardwood mixture C with average of properties for United States hardwood sulfate pulps

Pulp property	Colombian[2] hardwoods	United States[3] hardwoods
Bursting strength.....pts. per lb. per rm.[4]	0.83	0.88
Tearing resistance.....gm. per lb. per rm.[4]	1.50	1.01
Folding endurance..............double folds	220	420
Breaking length........................m.	7,450	8,500
Density........................gm. per cc.	0.63	....

1 At 350-milliliter freeness (Canadian Standard) interpolated from freeness versus strength and density curves.

2 Composite of digestions Nos. 4148, 4149, 4150, and 4151. Cooking conditions were: maximum temperature, 170° C.; time to maximum temperature, 1-1/2 hours; time at maximum temperature, 1-1/2 hours; sulfidity, 25.48 percent; liquor-to-wood ratio, 4:1; chemical concentrations, sodium hydroxide 37.5 grams per liter, sodium sulfide 12.5 percent; amount of chemicals (based on ovendry wood), total 20 percent, active alkali 15.6 percent; chemicals consumed, 86.6 percent of total chemicals; yield (based on ovendry wood) screened pulp, 48.3 percent, screenings, 0.3 percent; permanganate number of pulp, 17.4.

3 Average of comparable data for paper birch, sugar maple, American beech, red alder, sweetgum, and aspen.

4 Ream of 500 sheets, 25 by 40 inches.

Table 10.--Data on kraft wrapping papers and linerboards made from a mixture of Colombian hardwoods

Machine run No.	Sulfate pulp furnish: Colombian hardwood mixture (digestions 4148-4151)	Sulfate pulp furnish: Commercial northern pine	Jordaning	Headbox freeness (Canadian Standard)	Weight of 500-sheet ream: 24- by 36-inch sheet	Weight of 500-sheet ream: 25- by 40-inch sheet	Thickness	Density	Bursting strength: Mullen	Bursting strength: Unit	Average tearing resistance	Average tensile strength	Average folding endurance
	Percent	Percent		Cc.	Lb.	Lb.	Mils	Gm. per cc.	Pts.	Pt. per lb. per rm.[1]	Gm. per lb. per rm.[1]	Lb. per in. width	Double folds
						WRAPPING PAPER[2]							
4521	100	....	No	400	45.0	52.1	4.1	0.70	20.4	0.39	1.30	17.7	13
4522	100	....	Yes	295	48.8	56.4	4.0	.78	27.5	.48	1.28	23.1	33
4524	85	15	No	430	50.4	58.4	4.5	.72	23.2	.40	1.51	20.4	18
4525	85	15	Yes	....	48.8	56.4	4.0	.78	29.2	.52	1.29	24.0	53
4517	75	25	Yes	....	48.0	55.5	4.3	.71	21.5	.39	1.45	20.7	15
4518	75	25	Yes	335	51.0	59.0	4.4	.74	25.0	.42	1.44	22.8	19
4519	60	40	No	375	48.0	55.5	4.0	.77	28.7	.52	1.47	24.0	69
4520	60	40	Yes	240	48.6	56.2	3.8	.82	31.8	.57	1.30	27.4	130
[3]3484	....	....	....	....	43.5	50.4	3.7	.75	29.9	.60	1.41	22.2	128
						LINERBOARD							
[4]4523	85	15	Yes	390	....	168.6	14.0	.67	102.6	.61	1.67	75.5	....
Commercial boards[4,5]					....	146.9	12.5	.65	116.1	.79	2.47	66.2	....

[1] Ream of 500 sheets, 25 by 40 inches.

[2] 1-1/2 percent rosin size used in all wrapping-paper furnishes. White water pH adjusted to about 5. Calendering moderate.

[3] Commercial southern pine sulfate pulp.

[4] The average ring crush value was 124.5 pounds for machine run 4523 and 101.6 pounds for 3 commercial boards.

[5] The values are the average of tests on 3 commercial samples of 42-pound (per 1,000 square feet) southern kraft linerboards.

Table 14.--Data on newsprint and bond papers made from mixtures of Colombian hardwoods

Machine run No.	Pulp furnish: Colombian hardwoods: Amount	Pulp furnish: Colombian hardwoods: Process[1]	Pulp furnish: Southern pine sulfate	Jordaning	Headbox freeness (Canadian Standard)	Weight of 500-sheet ream 25- by 40-inch sheet	Thickness	Density	Bursting strength	Average tearing resistance	Average tensile strength	Average folding endurance	Air resistance (Gurley)	Opacity	Brightness (G. E. equivalent)	Castor oil penetration	Ash
	Percent		Percent		Cc.	Lb.	Mils	Gm. per cc.	Pt. per lb. per rm.	Gm. per lb. per rm.	Lb. per in. width	Double folds	Seconds per 100 cc.	Percent		Seconds	Percent
							NEWSPRINT[2]										
4526	50	Groundwood	20	No	165	34.2	3.4	0.56	0.17	0.97	5.0	2	8	85.6	59.8	19	....
	30	Neutral sulfite semichemical															
4527	50	Groundwood	20	Yes	90	35.2	3.7	.53	.26	.74	8.2	3	19	86.3	59.5	43	....
	30	Neutral sulfite semichemical															
4528	60	Groundwood	10	Yes	75	36.1	3.4	.59	.21	.54	6.5	1	21	88.0	59.0	34	....
	30	Neutral sulfite semichemical															
4622	50	Groundwood	20	No	150	37.7	3.4	.61	.19	.78	5.9	3	13	89.0	60.7	28	....
	30	Cold soda															
4623	50	Groundwood	20	Yes	95	37.4	3.7	.56	.21	.65	7.3	3	23	89.9	61.1	42	....
	30	Cold soda															
4624	50	Groundwood	10	No	105	37.0	3.6	.54	.18	.56	5.1	1	9	89.6	60.7	22	....
	40	Cold soda															
4643	30	Groundwood	20	Yes	....	38.1	3.8	.55	.24	.77	8.0	4	14	87.3	61.0	34	....
	50	Cold soda															
[3]4644	30	Groundwood	20	Yes	110	38.7	3.8	.56	.22	.75	7.0	3	11	87.7	63.0	24	5.9
	50	Cold soda															
Average of commercial newsprint papers						38.0	3.3	.64	.22	.54	8.4	....	52	92.0	58.0	50	....
							BOND[4]										
4529	100	Neutral sulfite semichemical		No	....	53.2	4.6	.64	.27	.98	12.5	3	2	81.3	83.4	11	4.8
4530	100	do		Yes	380	55.0	4.1	.74	.34	.88	17.0	7	8	81.2	82.6	18	5.3
4531	100	do		Yes	235	55.1	4.1	.74	.34	.86	17.1	8	9	82.5	82.8	21	5.4
4534	100	Sulfate		No	350	54.8	3.8	.80	.38	1.39	17.5	14	8	79.7	81.0	18	3.9
4535	100	do		Yes	240	53.8	3.5	.85	.46	1.20	20.1	36	30	79.2	80.7	41	4.5
A commercial bond made from spruce bleached sulfite						53.0	3.9	....	.52	1.10		....	....	....	....	....	6.7

[1] Groundwood indicates semibleached groundwood pulp (grinder run 1060); cold soda indicates semibleached cold soda pulp (digestion 4166); neutral sulfite semichemical indicates neutral sulfite semichemical pulp (digestion 5596N, semibleached, used for the newsprint, and digestion 5598N, fully bleached, used for the bond papers); and sulfate indicates sulfate pulp used for bond paper runs from digestions 4148 through 4152, fully bleached.

[2] 0.5 percent of rosin size added at beater. White water pH adjusted to about 5. Calendering moderate.

[3] 5 percent of clay filler added at machine chest.

[4] 5 percent of clay filler and 1 percent of rosin size added at beater. White water pH adjusted to about 5.

Table 12.--Nominal 1/2-inch insulation boards from mixture C of Colombian woods

Board No.	Furnish: Asplund stock[2]: Amount stock A	Furnish: Asplund stock[2]: Amount stock B	Furnish: Neutral sulfite pulp: Cook No.	Furnish: Neutral sulfite pulp: Freeness (Canadian Standard)	Furnish: Neutral sulfite pulp: Bursting strength	Furnish: Neutral sulfite pulp: Amount used	Sizing data: Rosin size	Sizing data: Alum	Sizing data: pH	Defibrator freeness	Drying data[1]: Temperature	Drying data[1]: Time	Board data: Density	Board data: Breaking load	Board data: Water absorption (by volume)
	Percent	Percent		Cc.	Pt. per lb. per rm.	Percent	Percent	Percent		Second	°C.	Hr.	Lb. per cu. ft.	Lb.	Percent
2026	85	....	5598N	225	0.47	15	0	0	7.6	24	150	3	15.6	7.2	....
2027	80	....	5598N	225	.47	20	0	0	7.6	31	150	3	16.9	9.6	....
2028	75	....	5598N	225	.47	25	0	0	7.6	43	150	3	18.1	12.8	80.2
2029	75	....	5598N	225	.47	25	0.5	1	4.2	44	150	3	18.1	10.9	4.2
2030	40	40	1248Y	305	....	20	.5	1	4.3	58	150	3	20.2	14.5	3.5
2031	37.5	37.5	1248Y	305	....	25	.5	1	4.2	75	150	3	23.7	18.9	3.8

SPECIFICATIONS FOR 1/2-INCH INSULATING BOARD[3]

	Breaking load (Lb.)	Water absorption (Percent)
Class A - building board	[4]10	[5]5
Class E - sheathing board	[4]14	....

[1] Mats were cold-pressed for 5 minutes at 100 pounds per square inch (gage) prior to drying in a forced-draft oven. Moisture content of mats for boards Nos. 2026 to 2029, inclusive, ranged from 61.7 to 62.2 percent. The moisture contents of mats for boards Nos. 2030 and 2031 were not determined but they should fall in the same range. Higher dewatering pressure is indicated for mats of boards Nos. 2026 to 2029, inclusive. Somewhat lower dewatering pressure is indicated for the last 2 board mats.

[2] Defibrator freeness of stock A after refining was 13 seconds; of stock B, 77 seconds.

[3] Federal Specifications LLL-F-321b, amendment 1, 1942.

[4] Minimum value.

[5] Maximum value.

Table 13.--Nominal 1/8-inch hardboard from mixture C of Colombian woods.

Board No.	Mill No.	Sizing data: Paraffin wax emulsion	Sizing data: Alum	Sizing data: pH	Defibrator freeness	Molding[1] temperature	Board data: Specific gravity	Board data: Modulus of rupture	Board data: Water absorption	Board data: Thickness change
		Percent	Percent		Second	°C.		P.s.i.	Percent	Percent
2012	119	0	0	7.5	37	195	0.98	6,150	67.4	35.2
2013	119	0.5	1	4.3	35	195	.98	3,810	44.2	35.0
2014	119	.5	3	4.3	37	195	.97	5,070	32.2	27.7
2015	119	1.0	1	4.2	37	195	1.00	4,930	27.7	24.8
2016	119	1.0	3	4.3	38	195	.96	4,400	25.2	24.3
2032	122	0	0	7.5	48	195	1.00	7,500	61.0	40.3
2033	122	0	0	7.5	48	195	1.00	8,420	42.2	23.0
2034	122	1.0	1.0	4.1	49	195	1.00	5,860	18.4	17.6
2035	122	1.0	1.0	4.1	50	195	1.00	6,440	16.2	15.4
SPECIFICATIONS FOR 1/8-INCH HARDBOARD[2]										
Class 1, type 1, untreated								[3]5,500	[4]20	[4]16

[1] Boards molded at maximum pressure of 500 pounds per square inch (gage) to reduce the water content to 60 percent or less. After 2 minutes at maximum, pressure was reduced to 100 pounds per square inch (gage) for a 1-minute breathing period, then increased to maximum again for 7 minutes. Boards 2033 and 2035 were then heated for 8 hours in a forced-draft oven at 145° C.

[2] Interim Federal Specifications (Fiberboard, Hardboard, Fibrous-felted) LLL-F-00311 (G.S.A.-FSS) Dec. 1953.

[3] Minimum value.

[4] Maximum value.