Tropical Products Institute

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Pulping characteristics of *Pinus caribaea* from Fiji: the effect of rate of growth

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E. R. Palmer and J. A. Gibbs

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Tropical Products Institute 56/62 Gray's Inn Road London WC1X 8LU
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SUMMARY

Pulping characteristics of *Pinus caribaea* from Fiji: the effect of rate of growth

Samples of *Pinus caribaea* Mor. var *hondurensis* Barr. and Golf. from Drasa and Seaqaqa in Fiji were sub-divided so that they represented the fastest and slowest growth rate on each site.

It was found that the fast growing trees yielded approximately twice the volume of wood yielded by the slow growing trees.

There were no significant differences in apparent wood density or chemical composition, in pulp yield or ease of digestion by the sulphate process or in the characteristics of the unbleached pulp.

In the absence of better information on which to base a selection programme, the limited evidence of this trial indicates that the best policy for the forester producing pulp wood is to adopt methods and to make selections to obtain high volume production.

RESUME

Caractéristiques papetières du *Pinus caribaea* de Fidji: l'effet de la vitesse de croissance

On a subdivisé des échantillons de *Pinus caribaea* Mor. var *hondurensis* Barr. et Golf. de Drasa et Seaqaqa en Fidji de sorte qu'ils représentent les espèces à vitesses de croissance la plus rapide et la plus lente pour chaque site.

On a trouvé que les arbres à croissance rapide donnaient approximativement deux fois le volume de bois donné par les arbres à croissance lente. Il n'y avait pas de différences significatives dans la densité apparente du bois, la composition chimique, le rendement en pâte, l'aptitude à la mise en pâte par le procédé au sulfate et les caractéristiques des pâtes écrues.

En l'absence de plus d'information pour établir un programme de sélection, cet essai tend à prouver que, pour l'exploitant forestier produisant du bois à pâte, la meilleure politique consiste à adopter des méthodes et à faire des sélections pour obtenir un volume de production élevé.

RESUMEN

Características de lejiado del *Pinus caribaea* procedente de las Islas Fiji: el efecto de velocidad de crecimiento

Muestras de *Pinus caribaea* Mor. var. *hondurensis* Barr. y Golf. procedentes de Drasa y Seaqaqa en las Islas Fiji fueron seleccionadas de tal manera que representaban las velocidades de crecimiento mayores y menores de cada lugar.

Se encontró que los árboles de un crecimiento más rápido proporcionan, aproximadamente, dos veces el volumen de madera producido por los árboles de crecimiento lento.

No hay diferencias significativas en la densidad aparente de la madera ni en la composición química, tampoco la hay en el rendimiento en pasta o facilidad de lejiación en el proceso al sulfato ni en las características de la pasta cruda.

A falta de una mejor información en la que se base un programa de selección, la limitada evidencia de este trabajo indica que la mejor política para el forestal productor de madera para pasta es el adoptar métodos y efectuar selecciones para obtener un volumen de producción alto.

Pulping characteristics of *Pinus caribaea* from Fiji: the effect of rate of growth

INTRODUCTION

In the course of examining more than 40 samples of *Pinus caribaea* Mor. var *hondurensis* Barr. and Golf. all grown from seed allegedly from the same provenance but planted in eight countries it was found that the pulping qualities varied considerably. A summary of the differences found has been published together with an attempt to suggest possible causes of differences in pulp quality by analysis of the results obtained on different samples. (Palmer and Tabb 1973)

One possible cause of difference was the rate of growth of the tree but the evidence available was inconclusive. In a trial reported in 1969 samples from two sites in Trinidad were examined. On each site a group of two hundred trees was marked and divided into three girth classes; from each girth class four trees were selected at random. All four trees were pulped together. There was no correlation between apparent wood density and growth rate on either site. The pulp obtained from the three samples of one site showed no significant difference in tensile and bursting strengths, but there were significant differences in tearing strength, the faster grown samples having lower tearing strengths. The samples from the second site did yield pulps with different properties; the sample with medium growth rate giving the lowest tensile, bursting and tearing strengths (Palmer and Gibbs, 1969).

The investigation being reported used samples of *P. caribaea* var *hondurensis* grown in Fiji and was designed to give more information on the effect of growth rate.

This report does not compare pulp from these samples with pulps available commercially because this has been reported using samples more representative of the material growing in Fiji, (Palmer and Gibbs, 1968, 1971 and 1972). Details of the growing conditions at Drasa and Seaqaqa have been reported (Palmer and Gibbs, 1972) and some details of the Fiji Pine Scheme have been reported by Sutton (1975).

SAMPLES

The samples used in these trials came from plantations planted in 1960 at Seaqaqa and 1961 at Drasa. Both samples were felled late in 1970 and were respectively 10 and 9 years old.

The selection of trees was the same from each plantation. Within the plantation an area of 300 trees was marked and the girth of each tree determined. Then ten trees were selected at random from 100 trees with the smallest girth and 10 from the 100 trees with the largest girth. From each tree logs were cut at 10%, 30%, 50%, 70% and 90% of the length of the bole to 7.5 cm diameter.

Although the logs were treated with a fungicide as soon as they were felled, they were badly stained by sap-stain fungus on arrival in London.

PLAN OF EXPERIMENT

Each group of 10 trees was treated as a separate sample. Thus four samples were examined:

Drasa Plantation, fast grown
Drasa Plantation, slow grown
Seaqaqa Plantation, fast grown
Seaqaqa Plantation, slow grown

Each sample was treated identically. The apparent density (oven dry weight/green volume) was determined on each log and from these measurements the mean density for each tree and for the whole sample calculated after weighting the individual measurements for the volume of the log.

A bulk sample was prepared by taking part of each log in proportion to its volume, and this bulk sample was used to obtain ground wood for chemical analysis and chips for pulping. Two sulphate digestions were made on each sample, in which the quantity of chemical applied was varied in order to obtain one pulp with a Kappa number that might be similar to that of pulp used for wrapping papers and a second pulp that was bleachable.

Details of experimental procedures are given in the Appendix.

RESULTS AND DISCUSSION

Rate of Growth

Details of the diameter at 10% of the height of each tree are given in Table 1 for the Drasa site and Table 2 for the Seaqaqa site. Detailed measurements of the height of each tree were not available, but assuming that the average height of the trees making up each sample was the same, the volume of wood produced by the fast grown trees

Table 1

Pinus caribaea **(age 9 years) from the Drasa site, Fiji**

Size and apparent density

Rate of growth	Tree number	Diameter of log at 10% of height, under bark (mm)	Apparent density of tree (kg/m3)	Density of least and most dense log within tree (kg/m3)	
Fast	3	172	512	414	552
	8	205	413	357	444
	9	193	387	344	412
	10	169	446	355	529
	13	174	377	343	391
	14	178	386	325	427
	15	192	393	370	405
	16	189	469	428	504
	17	185	386	339	443
	18	179	442	388	489
	Mean	184	421		
Slow	1	94	547	495	610
	2	125	450	380	516
	4	133	425	374	497
	5	139	427	369	480
	6	127	416	384	466
	7	117	477	396	562
	11	135	374	310	432
	12	138	396	361	428
	19	107	402	327	453
	20	122	567	515	581
	Mean	124	442		

Table 2

Pinus caribaea **(age 10 years) from the Seaqaqa site, Fiji**

Size and apparent density

Rate of growth	Tree number	Diameter of log at 10% of height, under bark (mm)	Apparent density of tree (kg/m^3)	Density of least and most dense log within tree (kg/m^3)	
Fast	4	188	408	348	454
	6	190	468	420	519
	8	190	504	463	553
	10	182	439	415	457
	12	205	438	396	470
	14	244	411	373	440
	15	220	484	438	498
	16	203	510	446	540
	17	228	439	421	456
	20	222	420	365	453
	Mean	207	450		
Slow	1	140	555	492	580
	2	135	516	457	588
	3	144	510	471	547
	5	134	445	407	471
	7	150	435	388	468
	9	157	348	322	379
	11	155	377	345	398
	13	167	500	466	517
	18	195	454	414	482
	19	144	532	499	549
		152	465		

on the Drasa site was more than double than that produced by the slow grown trees. On the Seaqaqa site one tree, number 18, was included in the slow grown sample, when it should have been in the fast grown sample. When allowance was made for this selection error, the volume of wood produced by fast grown trees on the Seaqaqa site was also double that produced by the slow grown trees.

Judged by the diameter of both fast and slow growing trees, the rate of growth at Seaqaqa was a little higher than at Drasa.

Apparent density

The apparent density (oven dry weight/green volume) for each log is given in Table 1 for the Drasa site and Table 2 for the Seaqaqa site.

On both sites the slow grown trees gave an average density slightly higher than the fast grown trees, but the difference was not significant. The variation of density within and between trees was greater for the slow grown samples; on both sites the logs with the lowest and highest density were found amongst the slow grown trees.

The overall average density was slightly higher for the Seaqaqa site.

Chemical analysis

The main chemical characteristics affecting the pulping properties of the wood are given in Table 3. There were no significant differences between fast and slow grown samples or between the sites.

Pulping and pulp evaluation

Details of the digestion conditions used and the pulp obtained in two sulphate digestions on each sample are given in Table 4. Differences in yield of pulp and ease of digestion between fast and slow samples were small.

Table 3

Pinus caribaea **from Fiji**

Chemical analysis

Site	DRASA		SEAQAQA	
Rate of growth	Fast	Slow	Fast	Slow
Alcohol-benzene solubility	1.3	1.1	1.7	1.8
Hot water solubility	2.0	2.3	2.3	2.4
1% NaOH solubility	11.2	11.0	11.4	12.3
Holocellulose	60.2	60.2	59.1	59.0
Alpha-cellulose	38.7	38.5	39.1	38.2
Lignin	28.6	28.6	28.6	29.0

All expressed as % oven-dry original wood

Table 4

Pinus caribaea **from Fiji**

Sulphate digestion data

Digestion conditions common to all cooks	
Sulphidity, per cent	25
Liquor to oven-dry wood ratio	6:1
Maximum temperature, °C	170
Time to reach maximum temperature, hours	1
Time at maximum temperature, hours	4

Site	DRASA				SEAQAQA			
Rate of growth	Fast		Slow		Fast		Slow	
Cook number	K515	K516	K514	K513	K519	K520	K517	K518
Digestion conditions								
Active Alkali as Na_2O% oven-dry wood	17.5	20	17.5	20	17.5	20	17.5	20
Active Alkali consumed as Na_2O% oven-dry wood	13.7	15.0	13.3	14.1	14.7	15.3	13.9	14.4
Pulp yield								
Yield of oven-dry digested pulp % oven-dry wood	44.0	42.3	45.5	43.3	45.5	43.3	45.4	42.8
Yield of oven-dry screenings on 0.15mm silts % oven-dry digested pulp	0.5	0.1	1.1	0.3	1.7	0.2	0.9	0.2
Yield of oven-dry screened pulp % oven-dry wood	43.8	42.2	45.0	43.2	44.7	43.2	45.0	42.7
Yield of oven-dry screened pulp/volume of wood, kg/m3	18.4	17.7	19.9	19.1	20.1	19.5	20.9	19.9
Pulp evalution								
Kappa Number of screened pulp	38.8	26.5	38.3	28.0	43.1	31.9	41.7	30.0

For the Drasa site the slow grown sample had the higher pulp yield and, as measured by screening rejects and the Kappa number of the pulp obtained with 20% Active Alkali, was more difficult to digest. For the Seaqaqa site the indications were the reverse, that was, that the fast grown sample had the higher pulp yield and was more difficult to digest. The fact that differences were small and in opposite directions for the two sites leads to the conclusion that there were no significant differences due to rate of growth.

When the yield of pulp from 1 m^3 of wood was calculated it was found that the slow grown samples yielded a little more pulp than the fast grown samples. However, this difference was small (around 8% for the Drasa site and 3% for the Seaqaqa site) and was more than offset by the greater volume of wood produced by the fast grown samples.

Details of the evaluation of the unbleached pulp are given for the Drasa site in Table 5 and for the Seaqaqa site in Table 6. The differences found were small. The overall impression was that pulps from slow grown samples were slightly more difficult to beat and gave slightly stronger pulps. The differences are illustrated in Figures 1 and 2. However, the differences were usually no greater than would be found in replicate beatings of the same pulp.

Table 5

Pinus caribaea **from the Drasa site, Fiji**

Evaluation of unbleached sulphate pulp beaten in PFI Mill

Rate of growth	Cook number	Yield oven dry pulp % oven dry wood: Total	Yield oven dry pulp % oven dry wood: Screened	Kappa number	Beating time (min)	Canadian Standard freeness	Drainage time (s)	Air porosity Gurley 100 cm3/ 6.45 cm2 (s)	Bulk (cm3/g)	Burst factor	Breaking length (m)	Stretch (%)	Tear factor	Double folds Koler-Molin 7.85N
Fast	K519	45.5	44.7	43.1	0	750	4.3	0.2	2.273	17.7	3292	3.7	180	60
					1	745	4.4	0.4	1.824	34.7	5331	4.9	178	1226
					2	700	4.4	0.8	1.739	42.6	6393	4.8	172	2175
					4	530	4.6	5.6	1.644	53.8	7617	4.9	171	2896
					6	340	5.0	38.1	1.588	55.9	7637	5.1	153	2805
Slow	K517	45.4	45.0	41.7	0	740	4.5	0.3	2.322	18.2	3126	2.8	175	53
					1	725	4.4	0.5	1.795	31.9	5099	5.5	189	569
					2	680	4.5	1.0	1.716	42.8	6544	5.3	195	1546
					4	560	4.6	3.3	1.649	49.7	7288	4.9	168	1774
					6	345	4.7	36.1	1.555	56.7	8051	4.4	143	2090
Fast	K520	43.3	43.2	31.9	0	745	4.4	0.2	2.384	14.5	2678	3.1	168	19
					1	715	4.5	0.5	1.795	32.7	5325	4.1	158	868
					2	675	4.6	1.0	1.725	41.7	6195	4.9	160	2102
					4	480	4.7	10.0	1.607	50.3	7039	4.3	143	2606
					6	250	5.4	97.6	1.528	51.8	7356	4.5	127	2972
Slow	K518	42.8	42.7	30.0	0	735	4.4	0.2	2.402	15.0	2803	3.1	159	28
					1	730	4.4	0.6	1.885	32.7	5216	4.4	162	505
					2	675	4.2	1.1	1.666	39.9	6119	4.6	146	897
					4	480	4.6	11.2	1.557	46.1	7140	4.2	129	1251
					6	290	5.1	100.3	1.508	49.0	7563	4.1	123	1539

Table 6

Pinus caribaea from the Seaqaqa site

Evaluation of unbleached sulphate pulp beaten in PFI Mill

Rate of growth	Cook number	Yield oven dry pulp % oven dry wood: Total	Yield oven dry pulp % oven dry wood: Screened	Kappa number	Beating time (min)	Canadian Standard freeness	Drainage time (s)	Air porosity Gurley 100 cm3/ 6.45cm2 (s)	Bulk (cm3/g)	Burst factor	Breaking length (m)	Stretch (%)	Tear factor	Double folds Koler-Molin 7.85N
Fast	K515	44.0	43.8	38.8	0	750	4.4	0.2	2.364	20.5	3633	3.5	163	63
					1	730	4.2	0.7	1.716	38.2	5751	5.0	169	1297
					2	685	4.5	1.6	1.620	45.2	6767	4.9	157	2106
					4	570	4.7	7.1	1.572	52.6	7485	4.5	148	2174
					6	365	4.8	60.0	1.512	56.1	8358	3.8	135	2525
Slow	K514	45.5	45.0	38.3	0	750	4.3	0.3	2.300	19.1	3281	4.0	188	88
					1	720	4.5	0.7	1.756	38.9	6244	4.5	180	1373
					2	700	4.5	1.1	1.628	44.0	6380	5.7	176	3174
					4	535	4.7	6.1	1.566	54.4	7846	4.6	151	2244
					6	340	5.0	38.8	1.527	57.5	8590	4.6	140	2536
Fast	K516	42.3	42.2	26.5	0	755	4.5	0.3	2.207	16.7	2697	2.4	151	29
					1	720	4.5	0.9	1.653	30.5	5283	3.9	127	341
					2	665	4.3	1.4	1.588	38.0	5968	3.6	113	583
					4	445	4.7	16.5	1.503	42.7	6532	4.3	108	1161
					6	255	5.8	59.2	1.442	49.3	7244	4.2	100	996
Slow	K513	43.3	43.2	28.0	0	745	4.4	0.3	2.238	19.0	3088	3.7	136	40
					1	725	4.5	0.7	1.726	32.4	4883	4.5	155	408
					2	670	4.6	1.6	1.654	42.8	6376	4.1	146	1360
					4	470	4.8	11.4	1.542	49.9	7447	4.6	128	1633
					6	280	5.4	96.3	1.493	53.5	7942	4.3	109	1725

Figure 1

Pinus caribaea from the Drasa site, Fiji
Comparison of the effects of growth rate on the characteristics of unbleached sulphate pulp

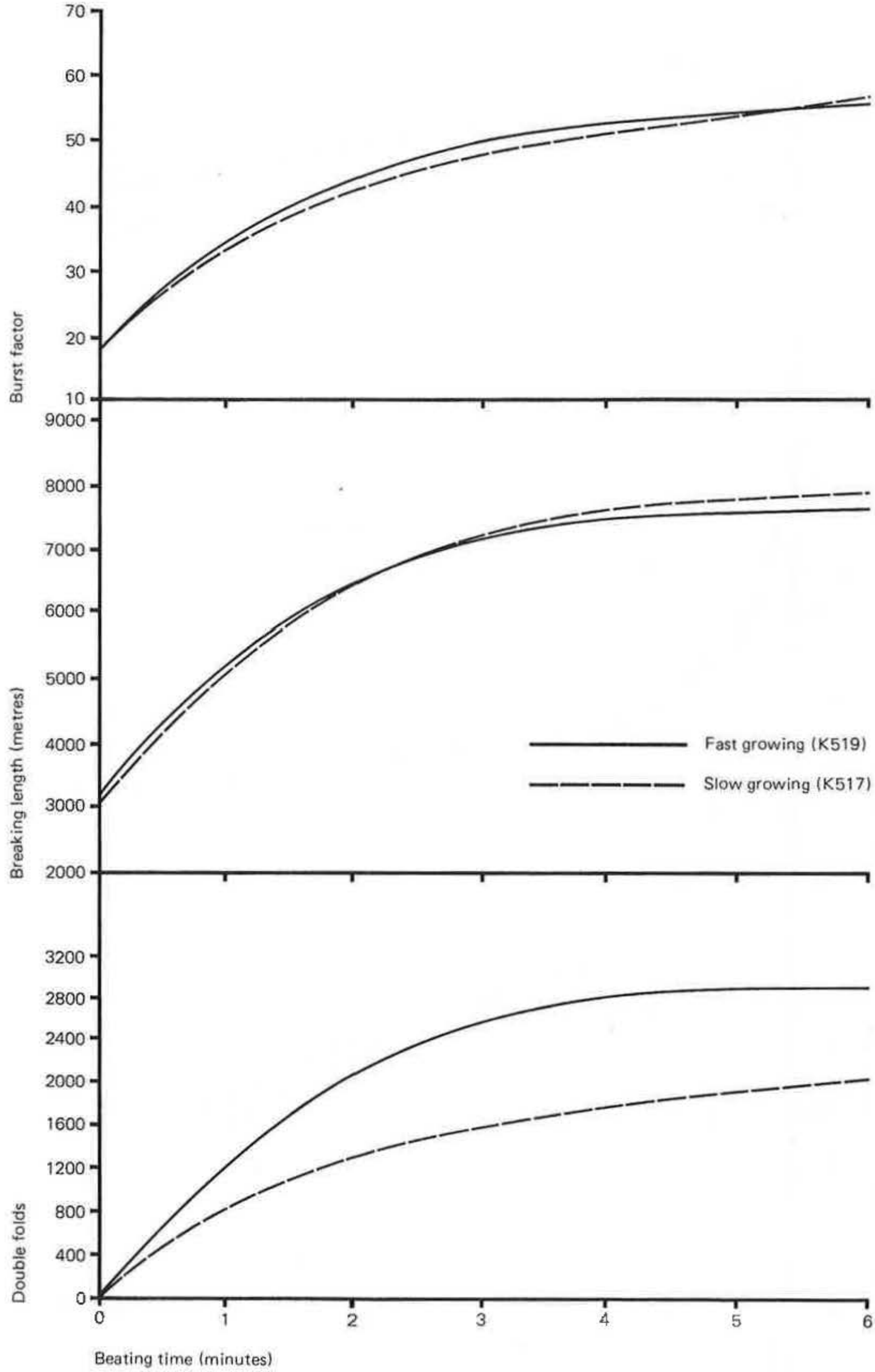


Figure 1 continued

Pinus caribaea from the Drasa site, Fiji
Comparison of the effects of growth rate on the characteristics of unbleached sulphate pulp

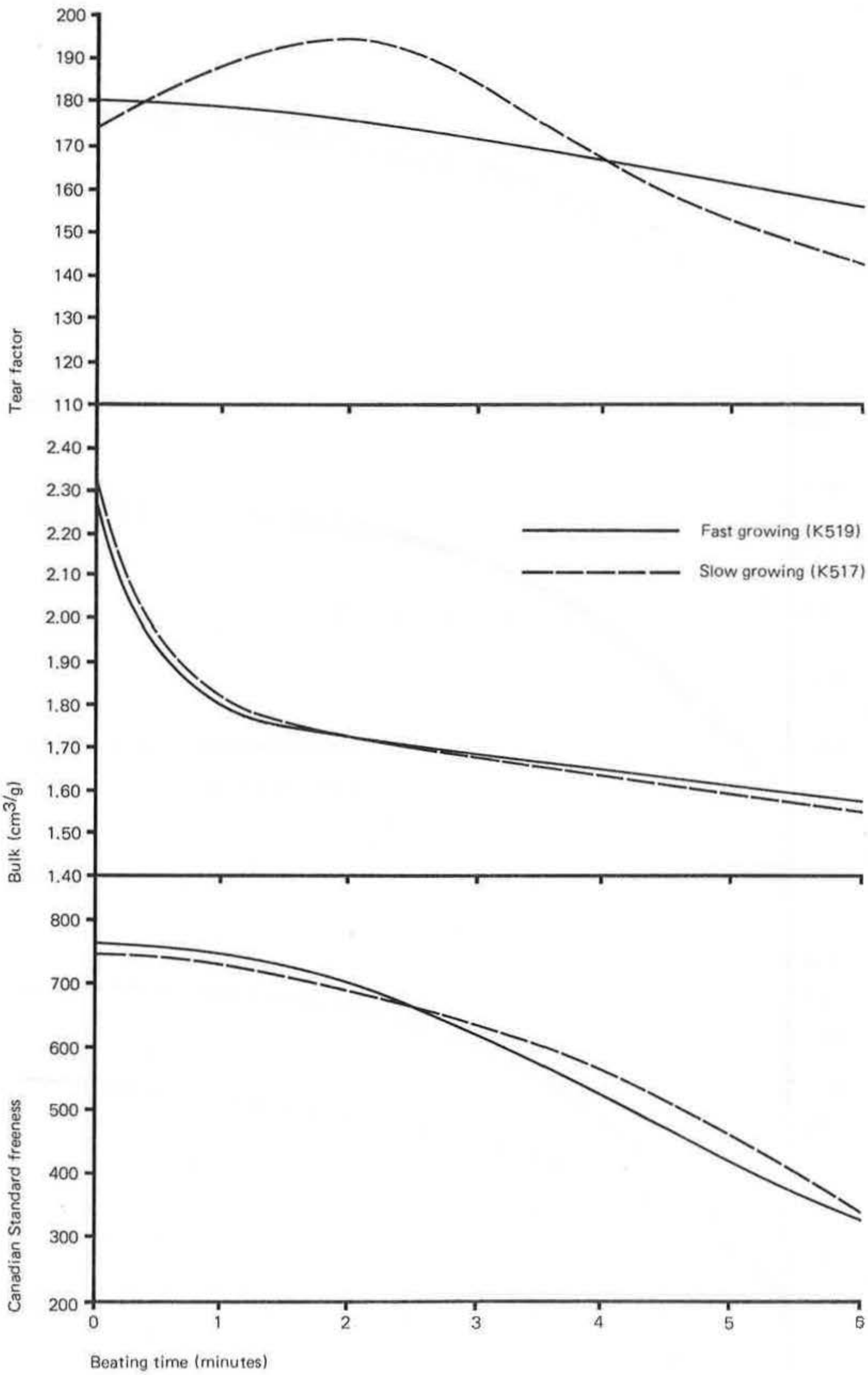


Figure 2
Pinus caribaea from the Seaqaqa site, Fiji
Comparison of the effects of growth rate on the characteristics of unbleached sulphate pulp

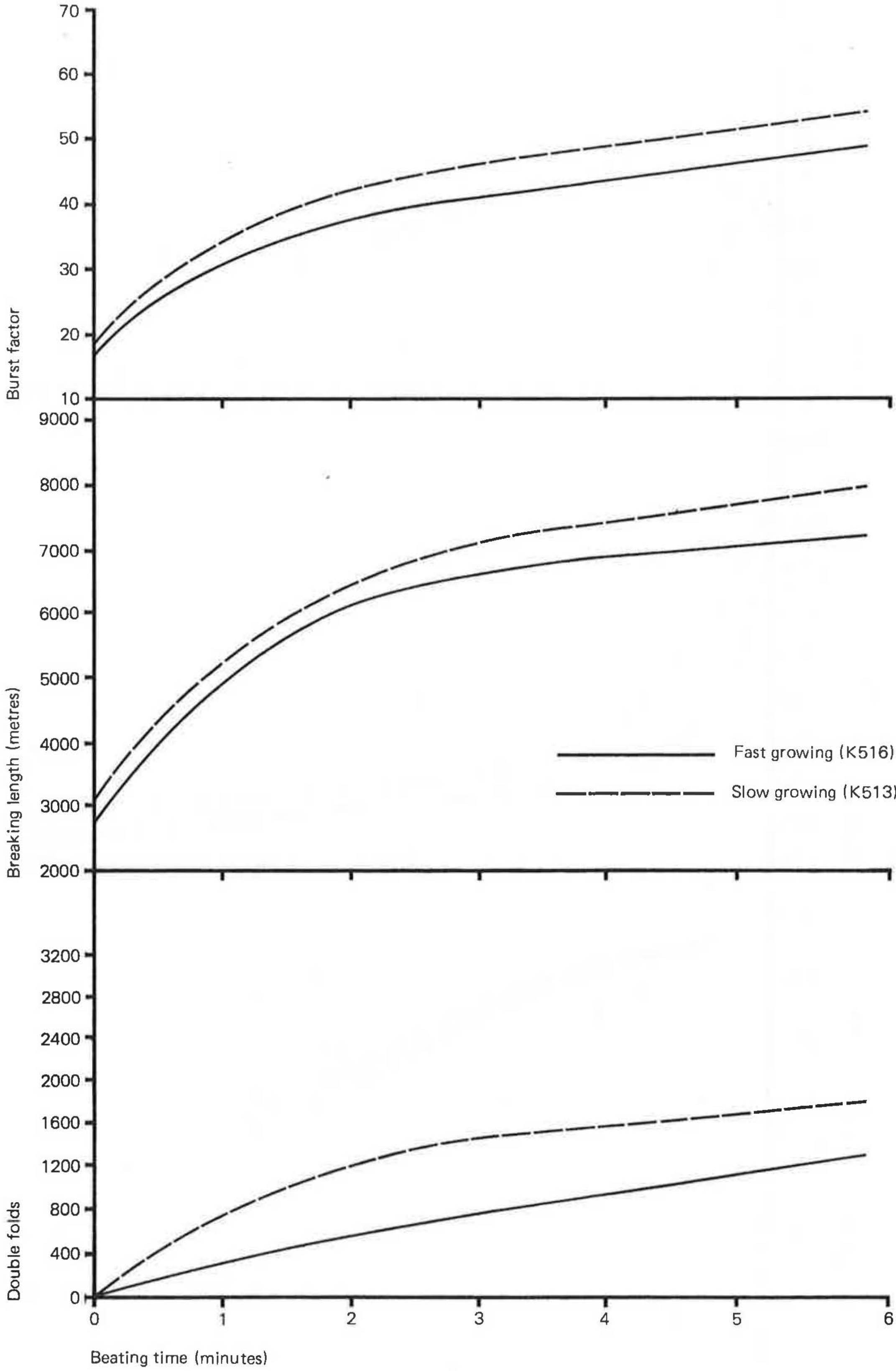
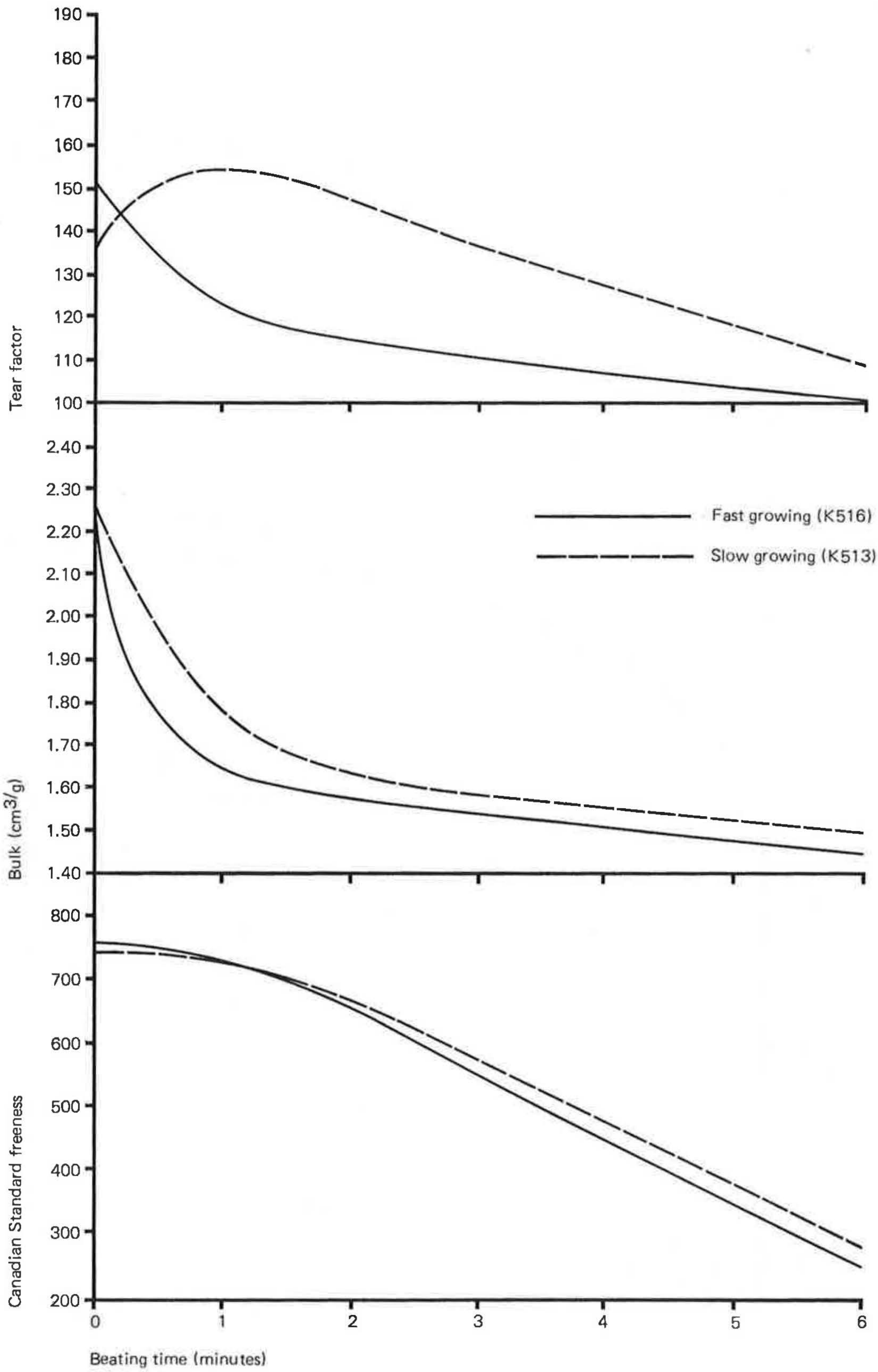


Figure 2 continued
Pinus caribaea from the Seaqaqa site, Fiji
Comparison of the effects of growth rate on the characteristics of unbleached sulphate pulp



CONCLUSIONS

1. The volume of wood produced by trees selected as fast grown was approximately twice that produced by the slow grown trees.

2. There was no significant difference in the density of the wood.

3. There was no significant difference in the chemical composition of the wood.

4. When cooked by the sulphate process there was no significant or consistent difference in the ease of digestion.

5. When compared as weight of pulp per weight of wood, the slow grown sample from Drasa yielded a little more pulp than the fast grown one; the samples from Seaqaqa showed the opposite trend.

   When compared as weight of pulp per volume of wood, the slow grown samples yielded more pulp than the fast grown ones: 8% on the Drasa site, 3% on Seaqaqa. The much higher volume increment of the fast growing trees more than compensates for the disadvantage of a slightly lower pulp yield.

6. There was an impression that pulps from slow grown samples were more difficult to beat and were stronger, but the differences were no greater than might be found in replicate beatings of the same pulp.

7. On the evidence of this trial, it can be concluded that the best course of action for the forester is to grow for volume production.

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Appendix

EXPERIMENTAL METHODS IN PULPING INVESTIGATIONS

1. Apparent density of wood

The method used was TAPPI Standard method T 18 m–53 using one piece approximately one inch thick from each log received.

The green volume was determined by weighing the disc, which had been soaked in water until it was saturated, immersed in water. The oven-dry weight was determined by weighing the disc after it had been dried to constant weight at 105° ± 3°C.

The apparent density is expressed as: $\dfrac{\text{oven-dry weight}}{\text{Green (soaked) volume}}$

2. Chemical analysis

The chemical analyses were carried out on a composite sample. A portion of the chips prepared for pulping trials was ground in an Apex knife mill and the fraction of groundwood which passed through a British Standard 40 mesh (420 microns) sieve and was retained on a British Standard 60 mesh (250 microns) sieve used for analysis.

The methods used were:

Alcohol benzene solubility	TAPPI T 6 m–59
Holocellulose	Wise, Murphy, D'Addieco
Alpha-cellulose	TAPPI T 203 os–61
1% Caustic soda solubility	TAPPI T 4 m–59
Lignin	TAPPI T 13 m–54

The fractions soluble in alcohol-benzene and 1% caustic soda are expressed as oven-dry extractives per cent oven-dry wood.

The alpha-cellulose and lignin are expressed oven-dry per cent oven-dry wood.

The holocellulose cellulose was dried by washing in acetone and storing at room temperature in a desiccator until constant weight. Under these conditions the holocellulose was found to have a moisture content of 2 per cent. In calculating the result allowance was made for this moisture content and the result is reported as oven-dry holocellulose per cent oven-dry wood.

3. Pulping methods

The chips used for pulping were prepared by sawing the log into discs approximately ¾ inch thick and then splitting along the grain with a mechanical guillotine to give a chip approximately ¾ inch x ¼ inch thick. This damages the fibres less than commercial chipping.

Laboratory pulping was carried out in an electrically-heated, stainless steel, rotating pressure vessel.

The method used was the sulphate (Kraft) process, which was selected as being the most promising process for use on tropical woods in tropical conditions. The active chemicals are sodium hydroxide and sodium sulphide.

The concentration of chemicals is calculated according to the following definitions:

(a) Active Alkali = $NaOH + Na_2S$ expressed as Na_2O per cent on oven-dry wood.

(b) Sulphidity = $\dfrac{Na_2S \times 100}{NaOH + Na_2S,}$ all the compounds expressed as Na_2O.

A sulphidity of 25 per cent was used in each of these experiments, chosen because published information shows there to be generally little variation in pulp quality with changes in sulphidity in the range of 20 to 30 per cent.

The cooked chips were washed free of superficial black liquor and broken up in a propeller type disintegrator to simulate the disintegration occurring during blowing a commercial digester; the pulp was screened using a plate with 0.15 mm wide slits, to remove shive, and collected on a 150 mesh (per linear inch) sieve.

The yield of pulp was determined by drying the whole of the screened pulp in a stream of air to about 10% moisture. The total weight of air dry screened pulp and the moisture content of an aliquot were determined for calculating the yield of oven-dry pulp.

The total alkali in the black liquor was determined by titrating an ashed aliquot of black liquor with hydrochloric acid. The Active Alkali remaining was determined by titrating an aliquot of black liquor after removing the sodium salts which are the reaction products of digestion by precipitation with barium chloride. The Active Alkali consumed was the difference of these results.

4. Unbleached pulp evaluation

The Kappa Number was determined by TAPPI standard method T 236 m–60. This method is identical with the International Committee for Chemical Analyses Method ICCA 1:59 which has been adopted throughout the world.

The amount of permanganate consumed by pulp under specified conditions is measured and, for pulp yields of less than 70 per cent, the percentage of Klason lignin approximately equals Kappa Number XO.15.

The pulp was evaluated by preparing and testing standard sheets, from pulp which had been air dried, according to the proposals of the 'Second Report of the Pulp Evaluation Committee to the Technical Section of the (British) Papermakers' Association'. The sheets of approximately 60 g/m^2 were tested after conditioning at 20° ± 1°C and 65 per cent relative humidity. The methods given in this report are practically identical with those in TAPPI Standard T 205 m–58. The effect of air drying is to lower the strength of the unbeaten pulp, but, except for specific scattering coefficient, the effect on beaten pulps is small.

The pulps were beaten in a PFI Mill using a pulp consistency of 10 per cent, a beating pressure of 3.4 kgF (33.3N) per cm of bar length and a difference between the peripheral speeds of the beating elements of 2 m/sec.

The methods used for physical examination of each set of sheets were:

(a) Thickness: Ten measurements made on ten sheets placed one on top of another using a dead weight micrometer.

(b) Breaking length and stretch; Twelve strips 15 mm wide tested using a Schopper-type tensile tester with the jaws initially 9 cm apart.

(c) Tear: Using a Marx-Elmendorf tear tester; normally a group of three were torn at one time through 44 mm in 2 places (i.e. total tearing distance is 3 x 2 x 44 = 264 mm), three readings being obtained in this way. Sheets with high tearing strength were torn either in pairs or singly and suitable adjustment was made to the calculation of the tear factor.

(d) Burst: Eighteen tests using a Frank Schopper-Dalen type pneumatic burst tester.

(e) Fold: 15 mm strips folded through 312° and the number of double folds recorded before the strip broke under a load of 7.85 N (800 gF).

(f) Air porosity: Four sheets tested using a closed top Gurley Densometer with a 20 ounce inner cylinder. The time for 100 ml of air to pass through 1 sq. inch was measured by the automatic timing attachment.

(g) Basis weight and moisture content: Determined by weighing six rectangles of 250 cm^2 after standard conditioning and after drying to constant weight at 105° + 3°C.

Results are reported as follows, where possible, independent of basis weight, but otherwise referring to an oven-dry basis weight of approximately 60 g/m^2.

Basis weight: Grams per square metre, oven-dry (W)

Thickness: Thickness of a single sheet, in microns.

Bulk* $\dfrac{\text{Thickness}}{W}$

Burst Factor* $\dfrac{\text{Average burst in } g/cm^2}{W}$

Tear Factor* $\dfrac{\text{Tearing force for a single sheet in g} \times 100}{W}$

Breaking Length* $\dfrac{\text{Average tensile strength in kg} \times 66\,700}{W}$

The result is expressed in metres.

*results which are independent of basis weight.

The ease with which water parts from the pulp was determined by two methods. The first, the drainage time determined on the standard sheet machine, is the time in seconds for water at 20°C to flow from a pulp suspension through the wire from a height 350 mm above the wire until the formed sheet is no longer immersed. The procedure used was that described in the 'Second Report of the Pulp Evaluation Committee' and is similar to that given in TAPPI Standard T 221 os–63.

The second, the Canadian Standard freeness is an empirical measure of the rate at which water will separate from a one litre suspension of 3 grams of pulp through a standard perforated plate, in apparatus calibrated by the Pulp and Paper Research Institute of Canada. The method is described in the 'Second Report of the Pulp Evaluation Committee, TAPPI Standard T 227 m–58 and in Canadian Pulp and Paper Association Standard C1.

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