THE WOOD AND PULPING PROPERTIES OF CHIR PINE (Pinus roxburghii Sarg.). PART II. LABORATORY PULPING STUDIES

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Abstract

The physical, anatomical and chemical properties of chir pine wood were described in the first part. The pulping studies on wood samples of this species on laboratory scale are presented in this article. Trial cooks were made to determine the most suitable kraft (sulphate) pulping conditions for producing bleachable pulp with Kappa number of about 25 from 15 chir pine trees of three age groups. In laboratory tests trees of 36–45 years age gave maximum pulp yield. However, handsheets prepared from the pulp of 26–35 years-old trees had higher breaking length and burst strength and lower tear strength than those of 36–45 years and higher age groups. The bleach response of pulps made from the three groups was almost identical and pulps of about 85°GE brightness were obtained after a four stage (CEH_1 H_2) bleaching sequence. The presence of resin in chir pine wood did not constitute any special problem during its pulping. The values of tall oil were found to be about 1% and 20–22 kg on oven-dry wood and per ton of oven-dry pulp basis respectively.

Introduction

The natural range of distribution of chir pine (***Pinus roxburghii*** Sarg.), its tree habits and wood quality were described in Part I of this series of articles (1). The pulping and paper making properties of wood samples of this species in laboratory tests are presented in this paper.

Material and Methods

Sampling procedure:–Fifteen dominant and co-dominant trees of chir pine ranging in age from 26 to 54 years were selected in compartment 3 (i) and (ii) in Batrasi Reserved Forest of Siran Forest Division in Hazara and felled at ground level. Total height, mid-height, and diameter at breast height were recorded for all trees. Total volume, over bark and under bark, was also determined for these trees. The trees were grouped on the basis of their age; 4 trees as G–1 (26–35 years), 5 trees as G–2 (36–45 years) and 6 trees as G–3 (46–54 years). One meter long billets from two positions with mid-point at breast height and mid-height and half meter long billet from top end (50 mm d.o.b) were cut and marked for tree number and their position in the tree. In all, 3 sample billets from each tree and 45 sample billets from 15 trees were obtained. 2.5 cm thick disc was sawn from each billet for wood and pulping studies in the laboratory.

Pulping trials:–Pulping trials were carried out on composite wood samples from discs for each group of trees. Discs were split along the grain to convert them into chips of approxi-

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mately 3 mm thickness. The chips were passed through a screen with one centimeter square openings to remove fine particles. Pulping was carried out by kraft (sulphate) process in a 15–litre capacity stainless steel, electrically heated, rotating digester. Six trials cooks were prepared to determine most suitable pulping conditions for producing bleachable pulp of chir pine with Kappa number of about 25. Considering pulp yield, Kappa number and strength properties of hand-sheets, the following conditions were found optimal for this purpose.

Active alkali as Na_20 on o.d. wood, % : = 18.
Sulphiality as Na_20 on o.d. wood, % : = 25.
Maximum temperature, °C : = 170.
Time at maximum temperature, hours : 4
Liquor to wood ratio = 5 : 1

The cooked chips were washed free of black liquor and disintegrated in a disintegrator. The pulp was passed through a 5 mesh screen with 3 mm square openings and collected on 100 mesh sieve. Pulp yield was determined on oven-dry wood-weight basis after drying of duplicate samples in an oven at 105 °C.

Black liquor was collected and its volume was measured. The excess alkali in the black liquor was determined by TAPPI Standard Method and tall oil content by the method of Saltsman and Kuiken (2) The tall oil content was computed by the following formula.

$$\text{Tall oil (\% of liquor solid basis)} = \frac{\text{g. tall oil residue obtained x 10}}{\text{g. solids in 10 ml of diluted liquor}}$$

From these values tall oil contents on the basis of oven-dry wood (%) and on oven-dry pulp (kg/ton) were calculated.

Kappa number:–The Kappa number of screened pulp was determined by TAPPI Standard Method T 236–os–76.

Bleaching trials:–Bleaching trials were carried out by a four stage sequence of (CEH_1 H_2), using chlorination with chlorine water (C), alkali extraction (E), and two stages hypochlorite bleach. The conditions for chlorination were determined by using the following formula developed at the laboratory of Pulp and Paper Technology, Norwegian Technical University, Trondneim, Norway.

% Cl on oven-dry pulp = Kappa number x 0.22.

Pulp evaluation:–Only unbleached pulp was evaluated. The pulp was beaten in a Valley Niagra Beater with a 5.5 kg load on the bed plate according to TAPPI Standard Method T 200–os–70. Standard hand-sheets from unbeaten and beaten pulp were made according to the TAPPI Standard Method T 205-om-81 and tested after conditioning at 23± 1 °C and 50± 2 percent relative humidity according to SCAN Method SCAN – P2:61. Freeness of the pulp was determined for both unbeaten and beaten pulps by the Schopper Riegler (°SR) Method according to SCAN-C19 65. Handsheets were tested according to TAPPI Standard Method T 227–05–71.

Results and Discussion

Under identical cooking conditions plup yield, Kappa number and active alkali consumption for all the three groups of trees e.g. G–1, G–2 and G–3 are given in Table 1.

Table 1. Pulp yield, Kappa number and active alkali consumption for three groups of chir pine trees.

		G–1	G–2	G–3
i.	Screened plup yield on oven-dry wood, %	42.1	44.2	43.6
ii.	Kappa number	25.5	25.5	23.6
iii.	Active alkali as Na_2O, consumed on added, %	85	86.2	86.2
iv.	Active alkali as Na_2O, consumed on oven-dry wood, %	15.3	15.5	15.5

The screened pulp yield of G–2 trees is slightly higher as compared to that of G–1 and G–3 trees. This may be due to the higher summerwood percent and wood specific gravity in the former than the latter groups of trees (1). If pulp yields of different groups are compared alongwith their Kappa numbers, then figures for G–2 and G–3 trees are quite similar. The strength properties of different pulps are presented in Table 2.

Table 2. Strenth properties of handsheets made from different groups of chir pine trees

Tree Group	Bulk cm 3/g 25 °SR	Bulk cm 3/g 45 °SR	Burst factor 25 °SR	Burst factor 45 °SR	Breaking length, metres 25 °SR	Breaking length, metres 45 °SR	Tear factor 25 °SR	Tear factor 45 °SR
G–1	1.52	1.35	80	86	10,400	11,300	120	112
G–2	1.65	1.48	70	77	9,200	9,700	150	137
G–3	1.65	1.45	70	74	9,200	9,600	148	127

Figures 1–4 also represent the comparison of strength properties of pulps from the three groups of chir pine trees at different freeness levels. The data show that at the same freeness

level, pulp made from G–1 trees produced a sheet of higher burst and breaking length and lower bulk and tear strength than that from G–2 and G–3 chir pine trees. Pulp made from G–2 trees had the highest bulk and tear strength among all the three groups of trees. However, in spite of these differences, pulps of three groups had acceptable strength properties.

Table 3 gives the comparative evaluation of laboratory made unbleached pulps from chir pine wood of different tree groups and some commercial pulpwoods. The strength properties in this table correspond to interpolated values at 25 °SR and 45 °SR for chir pine pulp (Valley beater) and 500 CSf and 300 CSf for other commercial pulps (PFI Mill beaten) (3). At comparable yields, chir pine pulp of G–1 trees has higher burst and breaking length but lower tear than *Pinus sylvestris*, U.K. grown, and mixed southern U.S.A. pines. On the other hand, G–2 and G–3 pulps have higher burst, breaking length and tear than mixed southern U.S.A pines, but lower breaking length and tear and higher burst than *Pinus sylvestris* pulp. On the whole chir pine pulp is quite comparable with pulp made from mixed southern U.S.A pines.

Table 3. Comparison of unbleached chir pine sulphate (kraft) pulps with those from other wood species.

	Species	Group No.	Yield on oven-dry wood %	Kappa No.	Bulk cm 3/g 25 °SR	Bulk cm 3/g 45 °SR	Burst Factor 25 °SR	Burst Factor 45 °SR	Breaking length m 25 °SR	Breaking length m 45 °SR	Tear Factor 25 °SR	Tear Factor 45 °SR
1.	*Pinus roxburghii*[1] (Pakistan)	G–1	42.1	25.5	1.52	1.35	81	86	10,400	11,300	120	112
		G–2	44.2	25.5	1.65	1.48	70	77	9,200	9,700	150	138
		G–3	43.6	23.6	1.65	1.45	70	74	9,150	9.600	148	128
2.	*Pinus roxburghii*[2] (India)	Twisted grain.	44.8	–	–	–	57.4		9000		95.9	
					500 CSf	300	500 CSf	300	500 CSf	300	500 CSf	300
3.	*Pinus sylvestris*[3] (U.K.)	–	45.2	36.0	1.47	1.40	70	74	10,000	10,500	165	155
		–	43.4	27.2	1.49	1.44	62	67	9,400	10,100	165	155
4.	Mixed Southern Pines[3] (U.S.A.)	–	45.1	40.8	1.53	1.50	60	64	8,500	9,000	185	175
		–	43.2	22.6	1.59	1.53	41	44	7,000	7,400	100	90

1. Values are based on conditioned basis weight
2. Values at 290 CSf
3. Values are based on oven-dry basis weight

Only one study has been reported in the literature so far regarding pulping properties of chir pine wood (4). This study was conducted on both laboratory and pilot scale in India for utilization of chir pine wood with twisted fibres for the manufacture of wrapping paper. The relevant data of this study are also given in Table 3. At comparable yields and freeness levels (considering 25 ^{o}SR as equivalent to 290 CSf), chir pine wood with twisted fibres produced a paper sheet of considerably lower strength properties as compared to those prepared in the present study from different trees with normal fibres.

Bleaching trials

The details of bleaching conditions are given in Table 4. The pulps made from all the three groups including the six initial trial cooks were bleached. The bleaching trials were carried out by using a four-stage sequence of chlorination (C): alkali extraction (E): hypochlorite (H1) and hypochlorite (H2). The amount of chlorine added in the first stage was calculated by the Kappa number of the unbleached pulp: the remaining stages were kept similar for all pulp samples.

Table 4. Four stage ($CEH_1 H_2$) bleaching results of the three groups of chir pine trees

		Tree G–1	Group G–2	G–3
1.	Unbleached pulp yiled on oven-dry wood, %	42.1	44.2	43.6
2.	Kappa number of screened pulp	25.5	25.5	23.6
3.	Total chlorine added as available chlorine on oven-dry pulp, %	10.1	10.1	9.7
4.	Total chlorine consumed on oven-dry pulp, %	9.3	9.5	8.5
5.	Yield of oven-dry bleached pulp on oven-dry wood, %	39.2	41.1	40.9
6.	Brightness			
	Unbleached pulp, (unbeaten), ^{o}GE	24	24	24
	CEH_1 bleached pulp unbeaten, ^{o}GE	78	78	78
	$CEH_1 H_2$ bleached pulp, unbeaten, ^{o}GE	83	85	84

From Table 4, it can be seen that the total amount of chlorine added to unbleached pulp varied from 9.7 percent to 10.1 percent; the chlorine consumed from 8.9 percent to 9.5 percent; the yield of bleached pulp from 39.2 percent to 41.1 percent and the brightness from 83

°GE to 85 °GE. It can also be seen from Table 4 that three-stage bleached pulp had brightness of 78 °GE for all the three groups which is poor as compared to that of imported commercial bleached pulps. On the other hand, four-stage bleached pulps had brightness of about 85 °GE which is comparable with the latter. It is also apparent that G–2 group of trees (cook–4) had higher bleached pulp yield and brightness than the other two groups of G–1 and G–3 trees.

Tall oil from sulphate black liquor.

The mean values of tall oil in the three groups are given below:

	Tree		Group
	G–1	G–2	G–3
Tall oil			
On oven-dry wood, %	0.93	0.92	0.88
On oven-dry pulp, kg/ton	22.14	20.72	20.14

The average recovery of tall oil was found to vary from 1 to 3 percent by weight of pine chips in different studies concluded in U.S.A. and Finland. However, a recovery of 4 to 5 percent of weight of wood has also been recorded in a Swedish study (5) Therefore, tall oil values obtained in the present study are lower than those reported in the literature. This may be due to its loss during long storage of 6 months of sample billets before the commencement of the study. It has generally been observed that the yield of tall oil from fresh pine wood decreases from 50 kg to about 20 kg per ton of sulphate pulp after the wood is stored for four months (6). The decrease occurred very rapidly in the case of green wood, and after one-month storage, the yield of tall oil was reduced to 55 to 60 percent of the original quantity present in fresh and non-stored wood. Furthermore, it was also observed in the present study that unwashed pulp contained considerable quantity of soft tall oil soap which could not be recovered and thus affected total tall oil recovery. Under the circumstances, it is expected that the actual recovery of the tall oil will be much higher than the figures given in this paper. It may also be mentioned here that high resin content in chir pine wood did not constitute any special problem during its pulping in the laboratory.

Summary and Conclusion

In this study of laboratory testing of kraft (sulphate) pulps from chir pine trees of three age groups, it was found that in general, pulp yield and strength properties of the handsheets were related to wood properties. The unbleached pulp yield varied from 42.1 to 44.2%. Maximum yield was obtained from wood specimens of 36–45 years old trees which had also exhibited the highest values of summerwood percent and wood specific gravity. The kraft pulps prepared from chir pine trees had acceptable strength properties and were quite comparable in both yield and quality with those of commercial pulps made from mixed southern U.S.A. pines and some European pines. It was also found that chir pine pulp could be bleached to a brightness of about 85 ^{O}GE by a four stages sequence of chlorination, alkali extraction and hypochlorite (H_1, H_2). The imported long-fibre pulp has about the same brightness. Further, the recovery of Tall oil was rather low, e.g., about 1% and 20–22 kg on oven-dry wood and per ton of oven-dry pulp basis respectively. It could be improved if fresh chips are used for pulping. However, no pitch problem was encountered during pulping and sheet making. On the basis of the results of this study, it can be concluded that chir pine kraft pulp can be used in place of imported long-fibre pulp.

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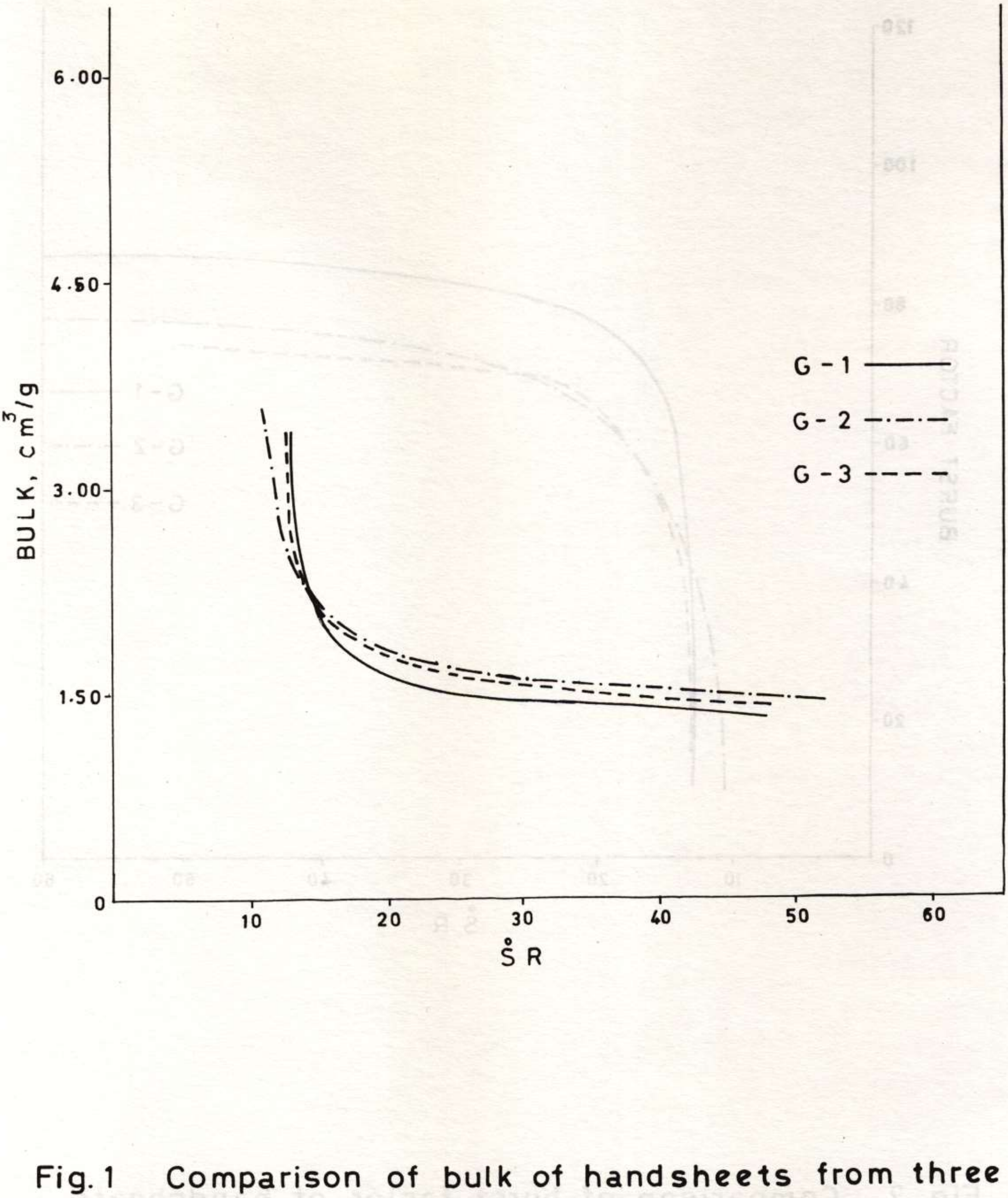

Fig. 1 Comparison of bulk of handsheets from three groups of chir pine trees at different freeness levels

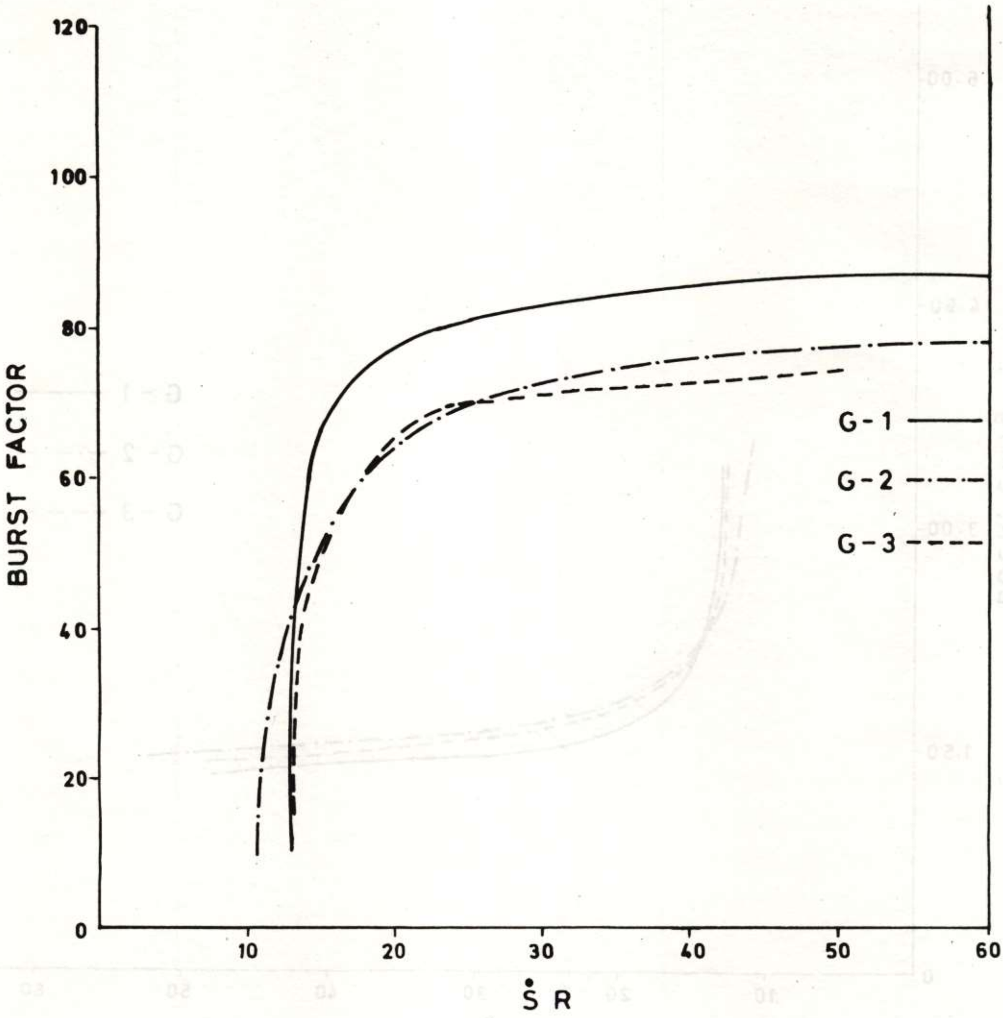

Fig. 2 Comparison of burst factor of handsheets from three groups of trees at different freeness levels

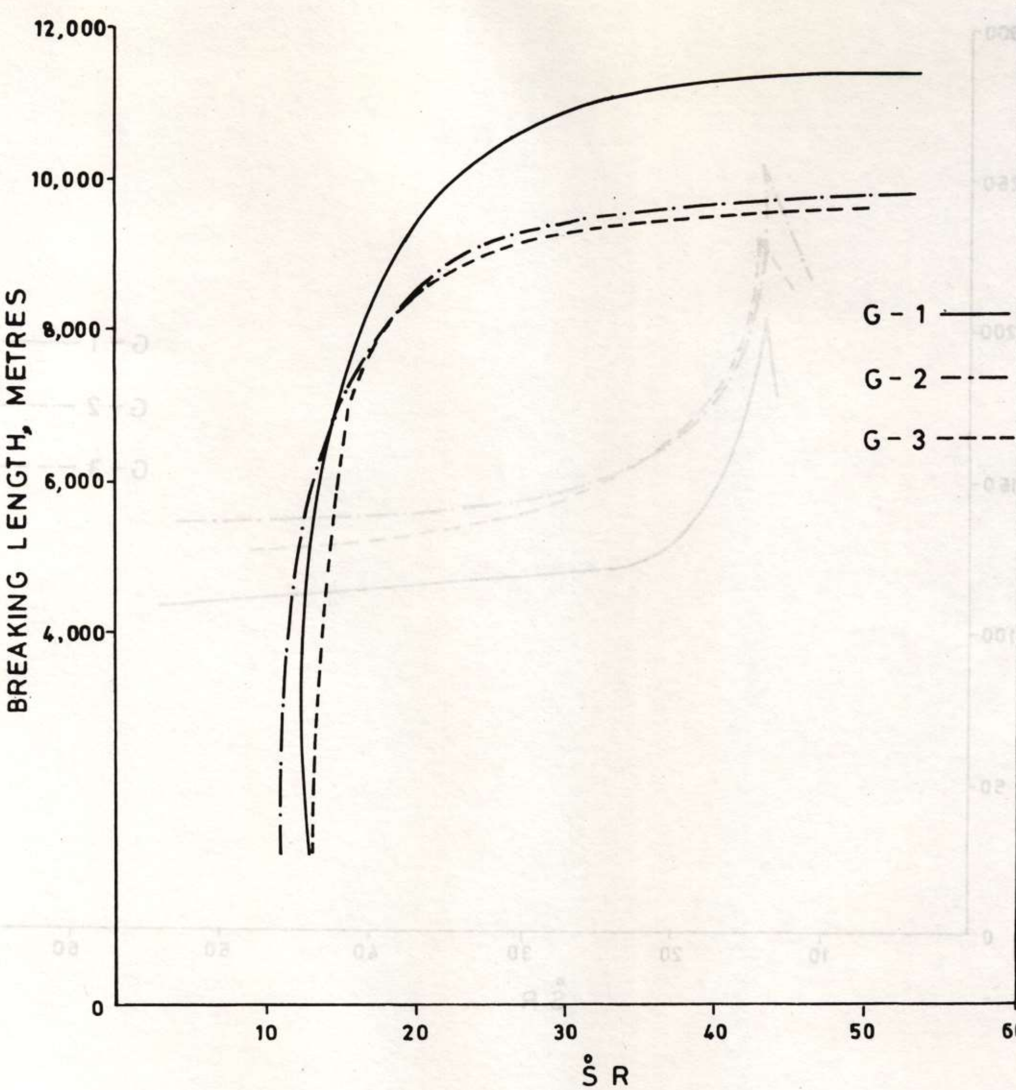

Fig. 3 Comparison of breaking length, m, of handsheets from three groups of tree at different freeness levels

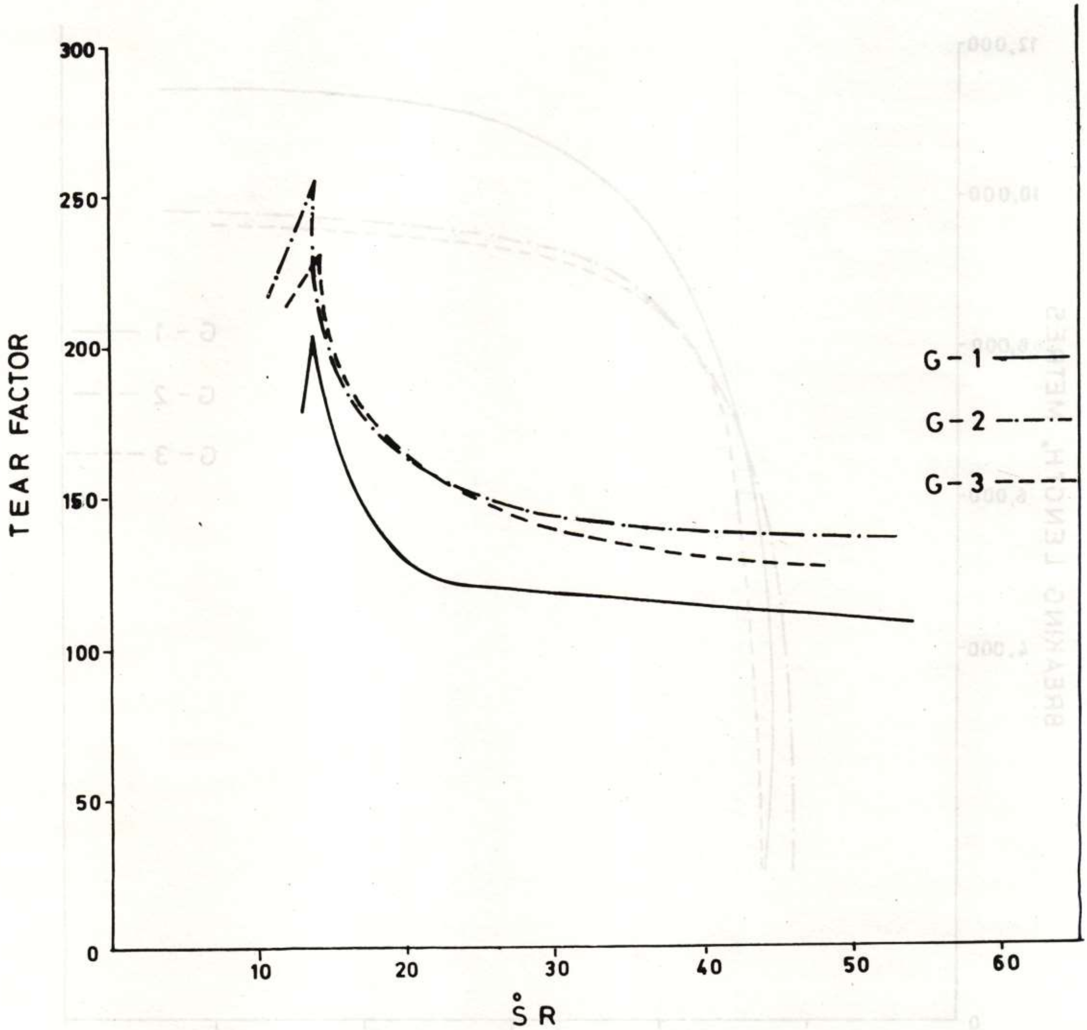

Fig. 4 Comparison of tear factor of handsheets from three groups of trees at different freeness levels