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LABORATORY SCALE PULPING OF *Pinus pseudostrobus*, *P. maximinoi* AND *P. patula*

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ABSTRACT – Laboratory scale pulping (1.0 Kg) was conducted on individual trees of ***Pinus pseudostrobus*** Lindley, ***P. maximinoi*** H.E. Moore and ***P. patula*** Schiede and Deppe of similar age and grown under the same environmental conditions. In terms of pulping properties, ***P. pseudostrobus*** had the lowest kappa number and the highest pulp yield. The burst index of ***P. patula*** and ***P. pseudostroubs*** were similar and were superior to that of ***P. maximinoi***. The range of values for the pulp and paper-making traits of ***P. patula*** were less than that of the other two species.

RESUMEN – La scala de pulpeo en el laboratorio (1.0 kg) se llevó a cabo em árboles individuales de ***P. pseudostrobus*** Lindley, ***P. maximinoi*** H.E. Moore and ***P. patula*** Schiede y Deppe, com edades similares y com crecimiento de iguales condiciones ambientales. Em términos de propiedades de pulpeo, el ***P. pseudostrobus*** tuvo el menor número kappa y el mayor rendimiento de pulpa. Los índices de explosión fueron similares em el ***P. patula*** y em ***P. pseudostrobus*** y superiores al del ***P. maximinoi***. Los valores de la pulpa y lãs características de producción de papel de ***P. patula*** fué menor que el de lãs otras dos espécies.

INTRODUCTION

It has been recognized for quite some time that ***Pinus pseudostrobus***Lindley has considerable potential for afforestation in Southern Africa (POYNTON, 1979). Seed imports of this species into South Africa began in 1908 (POYNTON, 1979) thought the species tendency to have heavy branches in whorls has limited its planting as a sawtimber species.

Provenance trials of ***P. pseudostrobus***(KEMP, 1973) were established in Southern Arica at several sites during the 1970's using seed collected in Central America by staff of the Instituto Nacional de Investigaciones Forestales (INIF) and the Oxford Forestry Institute (OFI). Since the time of the original collections, several of the ***P. pseudostrobus*** provenance have been reclassified as ***P. maximinoi*** H.E. Moore (MITTAK & PERRY, 1979; and STEAD, 1983). Both ***P. pseudostrobus*** and ***P. maximinoi*** can produce more volume per hectare under certain environmental conditions in Southern Africa than the

more commonly planted species of ***P. patula*** Schiede and Deppe and ***P. elliottii*** Engelm. (KIETZKA, 1988). The rapid growth rate of ***P. maximinoi*** has also been observed in Honduras (HOUKAL, 1983), Colombia (LADRACH, 1984; URREGO & LAMBETH, 1988) and Brasil (PIRES et alii, 1987). However there are few published reports giving details of the wood, pulp and paper-making properties of ***P. pseudostrobus*** and ***P. maximinoi.***

Within its natural range, ***P. maximinoi*** is reported to have an unextracted gravimetric density equal to that of ***P. oocarpa*** Schiede but less than that of ***P. patula*** Schiede and Deppe ssp. ***Tecunumanii*** (Eguiluz and Perry) Styles DVORAK & Donahue, 1988). In Colombia, (LADRACH, 1986) found the wood density of ***P. maximinoi*** and ***P. pseudostrobus*** to be very similar. In that study ***P. oocarpa*** had a higher wood density than either ***P. maximinoi*** or ***P. pseudostrobus*** though wood of these species did exceed the density of ***P. patula*** and ***P. kesiya*** Royle ex Gordon. When grown as an exotic in South Africa, ***P. maximinoi*** produced wood with a higher gravimetric density than ***P. patula*** and a lower density than ***P. patula*** ssp. ***Tecunumanii*** (WRIGHT, s.d.). Also in South Africa, twelve year old ***P. pseudostrobus*** was compared to ***P. patula*** for stone groundwood in amill scale test (SMITH, 1980). The physical strength properties (breaking length, and the indices of tear and burst) of ***P. pseudostrobus*** were as good or better than those of ***P. patula***. Given the potential for afforestation of ***P. pseudostrobus*** were as good or better than those of ***P. patula***. Given the potential for afforestation of ***P. pseudostrobus*** and ***P. maximinoi***, a study was understaken to evaluate their chemical pulp and paper-making properties.

MATERIALS AND METHODS

A provenance trial of ***P. pseudostrobus*** and ***P. maximinoi*** was established on the Helvetia plantation of Sappi (Pty) Ltd in January, 1978, with seed supplied by the OFI. The area near trial was planted to ***P. patula*** of seed orchard origin. The Helvetia site is at an altitude of 1640m with a mean annual rainfall of 850mm which is confined mainly to the summer months. The mean annual temperature is 15^{o}C and during the dry winter months minimum temperatures of -10^{o}C can occur.

The trial was sampled at an age of 10.5 years. Ten trees each of ***P. pseudostrobus*** and ***P. maximinoi*** and five trees of ***P. patula*** with above average growth rates were selected and the bark thickness and diameter measured at a height of 1.4m above ground. The trees were felled and the total height to a top diameterof 5cm was measured. Each tree was devided into height interval of ten per cent and a disc of 2cm thickness was taken at the top of each height interval. The discs were kept separate by tree were transported to the Enstra Research Centre of Sappi.

The discs were chipped to a uniform thickness of 2-3mm. Chip uniformity is critical to insure equal penetration by the pulping liquor. Following moisture determination, every timber sample was kraft pulped under standard conditions (Table 1). The pulp was washed and the yield determined by dividing the oven dried weight of fibre by the oven dried weight of wood. A sample of the pulp was then tested for residual lignin content (kappa number) and of the remaining, pulp, three samples were taken. One sample was kept in the unrefined state (nil beating) while the other two samples were refined in a PFI mill at 2250 and 9000 revolutions, respectively. From the three samples, hand sheets were made and conditioned prior to testing to paper strength traits. Growth, pulp and paper-making data for

the individual trees are contained in Table 2 and 3. The ***P. maximinoi*** was sampled for a fourth beating point of 18000 revolutions.

Table 1. Kraft pulping conditions.

Max. Temp., (^{o}C)	170
Time to 170^{o}C, min.	110
Time at 170^{o}C, min.	60
Liquor: wood	5.4:1
Active alkaline, % as Na_2O	22
Sulfidity, %	26

RESULTS AND DISCUSSION

No statistical comparisons were undertaken since this study was to determine if further trials or limited afforestation with ***P. pseudostrobusn*** and ***P. maximinoi*** are warranted. The mean values for volume per tree of the three species were almost equal though these volumes do not necessarily indicate the potential of this specific site. The tree mortality in this trial was not evaluated but the ***P. maximinoi*** did not have the survival of the other two species and this was likely due to frost. The wood density of ***P. pseudostrobus*** was lower than that of ***P. patula*** and ***P. maximinoi***. However, wood density has not been found to be a realiable indicator of pulp and paper strength properties in a number of pine species growing in South Africa (WRIGHT, 1990).

Table 2. Volume, wood and pulping properties of ***P. patula*** (PAT), ***P. maximinoi*** (MAX) and ***P. pseudostrobus*** (PSE) sampled at Helvetia, Eastern Transvaal, at an age of 10.5 years.

Species	Tree N^o	Vol. (m^3)	Density (Kg m^{-3})	Kappa N^o	Pulp Yield	Kg Fibre/Tree
	1	0.092	421	57.0	48.26	19
	2	0.163	426	57.8	47.85	33
PAT	3	0.160	484	62.8	47.63	37
	4	0.148	470	60.6	46.68	32
	5	0.211	421	55.5	45.79	41
	Mean	0.155	444	58.7	47.24	32
	Min	0.092	421	55.5	45.79	19
	Max	0.211	484	62.8	48.26	41
	1	0.121	453	68.1	48.58	27
	2	0.103	453	62.1	48.99	23
	3	0.120	446	54.8	45.62	24
MAX	4	0.179	505	55.2	47.05	43
	5	0.129	399	64.5	46.74	24
	6	0.133	494	59.5	46.45	31
	7	0.300	476	51.1	45.04	64
	8	0.155	434	44.8	44.56	30
	9	0.209	442	45.5	41.90	39
	10	0.081	460	52.2	44.81	17
	Mean	0.153	456	55.8	45.97	32
	Min	0.081	399	44.8	41.90	17
	Max	0.300	505	68.1	48.99	64
	1	0.148	419	49.7	48.43	30
	2	0.096	497	55.4	47.62	23
	3	0.224	383	60.6	46.91	40
PSE	4	0.138	387	52.9	48.48	26
	5	0.173	322	58.6	45.38	25
	6	0.166	398	55.1	47.63	31
	7	0.155	416	50.0	46.98	30
	8	0.130	395	45.3	46.69	24
	9	0.210	424	48.4	47.45	42
	10	0.172	421	50.9	47.64	34
	Mean	0.161	406	52.7	47.32	31
	Min	0.096	322	45.3	45.38	23
	Max	0.224	497	60.6	48.48	42

In terms of pulping properties, ***P. pseudostrobus*** had the lowest kappa number and the highest pulp yield of the tree species. The minimum and maximum values for pulp yield of ***P. pseudostrobus*** were almost exactly the same as those of ***P. patula***. In the digestor, a wood with relatively uniform pulp yield allows the operator to more easily cook the chips to a standard kappa number. The kilogrammer of fibre per tree is the product of volume,

wood density and pulp yield. This is the most important trait if the paper strength traits are acceptable. The three species sampled at Helvetia were almost equal for mean kilogrammer of fibre per tree.

Table 3. Paper strength properties of ***P. patula*** (PAT), ***P. maximinoi*** (MAX) and ***P. pseudostrobus*** (PSE) from 10.5 year old trees at Helvetia, Eastern Transvaal. The number of revolutions (x100) the pulp was beaten in the PFI mill are given below the paper strength properties.

Species	Tree	Burst Index				Tear Index				Breaking Lenght			
	N°	Nil	225	900	1800	Nil	225	900	1800	Nil	225	900	1800
PAT	1	5.2	6.5	7.6	-	11.3	9.8	7.9	-	6777	8865	9504	-
	2	5.3	7.1	7.6	-	11.7	10.1	9.7	-	7919	10354	11881	-
	3	4.8	6.2	7.1	-	13.9	10.5	9.0	-	6331	8409	10092	-
	4	4.7	6.4	7.2	-	10.9	9.7	7.6	-	6993	9620	11395	-
	5	4.0	5.6	6.9	-	12.0	10.5	8.8	-	6354	8627	11493	-
	Mean	4.8	6.4	7.3	-	12.0	10.1	8.6	-	6873	91.75	10873	-
	Min	4.0	5.6	6.9	-	10.9	9.7	7.6	-	6331	8409	9504	-
	Max	5.3	7.1	7.8	-	13.9	10.5	9.7	-	7919	10354	11881	-
MAX	1	4.8	5.7	7.3	6.9	12.6	10.1	8.2	7.7	5828	8045	9598	9795
	2	4.1	6.3	7.2	6.9	11.3	8.2	7.4	6.6	6617	8386	9925	11377
	3	4.7	5.6	6.6	-	14.3	10.2	8.5	-	6468	8003	9730	-
	4	2.9	5.7	7.1	7.5	16.9	11.3	9.6	9.3	5069	7544	9484	9267
	5	4.9	6.0	6.5	7.0	12.7	9.1	8.8	8.3	5988	7577	8638	8450
	6	4.3	5.7	6.7	7.4	14.3	0.2	9.4	9.0	5502	7540	9456	10319
	7	3.7	5.4	7.4	7.2	15.1	11.5	9.4	8.3	5396	7310	9575	9678
	8	4.5	5.4	7.0	7.3	14.4	11.2	9.0	7.5	5250	7200	8471	9658
	9	4.7	5.7	6.4	6.7	11.8	8.3	7.2	6.7	5842	7476	8966	9681
	10	4.4	5.9	6.3	7.3	11.6	8.2	7.3	7.3	5626	7943	9763	9382
	Mean	4.3	5.7	6.9	7.1	13.5	9.8	8.5	7.9	5759	7700	9361	9734
	Min	2.9	5.4	6.3	6.7	11.3	8.2	7.2	7.3	5069	7200	8471	8450
	Max	4.9	6.3	7.4	7.5	16.9	11.5	9.6	9.3	6617	8360	9925	11377
PSE	1	4.5	6.1	6.9	-	15.9	9.2	6.9	-	5831	7751	9849	-
	2	3.6	5.4	6.9	-	15.6	13.0	10.5	-	5447	7497	9093	-
	3	4.6	6.1	6.8	-	14.9	10.1	8.5	-	5675	6887	9698	-
	4	5.1	7.3	8.3	-	11.2	9.5	8.3	-	8067	10404	12153	-
	5	5.7	6.9	7.4	-	8.9	7.5	6.9	-	6987	11000	9974	-
	6	4.5	6.3	7.7	-	10.4	8.8	7.9	-	7131	9674	11636	-
	7	5.0	6.8	8.0	-	9.9	8.0	7.2	-	6929	9689	10508	-
	8	4.7	6.3	7.8	-	13.8	11.6	10.0	-	7180	8403	10911	-
	9	4.3	5.9	7.3	-	12.5	10.2	9.2	-	6916	8700	11262	-
	10	5.1	6.4	7.2	-	13.7	10.5	7.2	-	7024	8451	9120	-
	Mean	4.7	9.8	8.3	-	12.7	9.8	8.3	-	6719	8846	10420	-
	Min	8.9	7.5	6.9	-	8.9	7.5	6.9	-	5447	7497	9093	-
	Max	15.9	13.0	8.3	-	15.9	13.0	10.5	-	8067	11000	12153	-

The mean burst index of ***P. patula*** and ***P. pseudostrobus*** was better than that of ***P. maximinoi***. By contrast, the tear index of ***P. maximinoi*** was much higher when unrefined compared to the other two species. However, with refining in the PFI mill, pulp of ***P. pseudostrobus*** and ***P. patula*** developed better burst index at almost equal values of tear index relative to ***P. maxininoi*** (Figure 1). Individual trees of the three species were compared for the indices of burst and tear (Figure 2). From this figure it can be seen that the best and worst tree evaluated in the trial was ***P. pseudostrobus***. The trees of ***P. patula*** were the most uniform in terms of the burst versus tear curve suggesting that selection for growth rate and from characteristics may have inadvertently reduced the variation in paper strength traits. At a wetness of 15.0, the pulps would have very similar values of burst index (Figure 3) though the ***P. patula*** would have a higher tear index (Figure 4). The importance of wetness will depend on the intended end product and the extent to which laboratory determinations reflect those of the mill.

The ***P. maximinoi*** samples that were refined at 18000 revolutions in the Lampen mill gave very little additional information. For this reason the ***P. patula*** and ***P. pseudostrobus*** samples were refined at only three levels.

CONCLUSION

The paper strength traits of ***P. pseudostrobus*** were almost equal to those of ***P. patula*** in this chemical pulping trial confirming the results of (SMITH, 1980) using the stone groundwood process. The higher pulp yield and lower kappa number of ***P. pseudostrobus*** would indicate that further work with the species is warranted. Trials of ***P. maximinoi*** from a range wide provenance collection have been planted in South Africa and will indicate the growth potential of this species.

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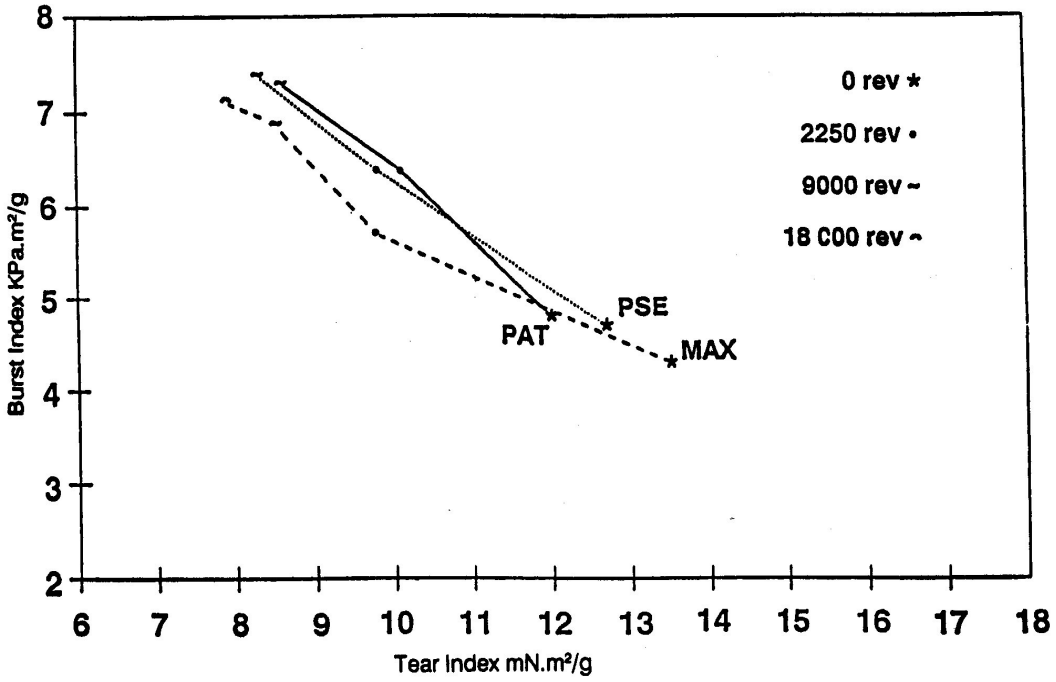

Figure 1 - Beating response curves for pulp from the whole tree (mean values).

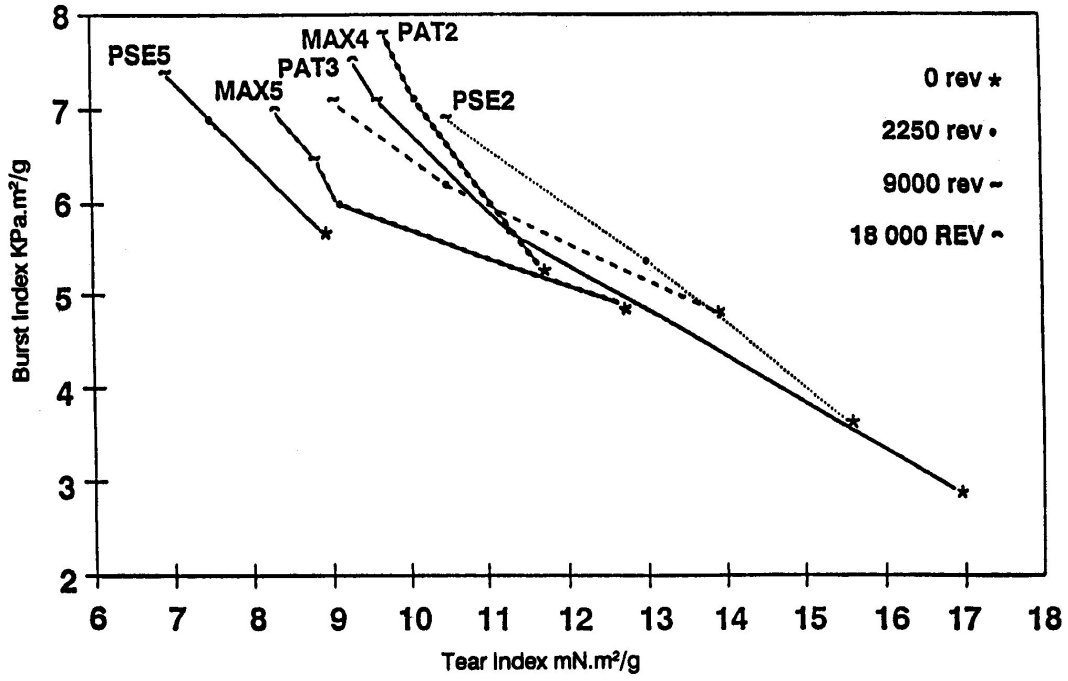

Figure 2 - Beating response curves for pulp from the whole tree (individual tree values).

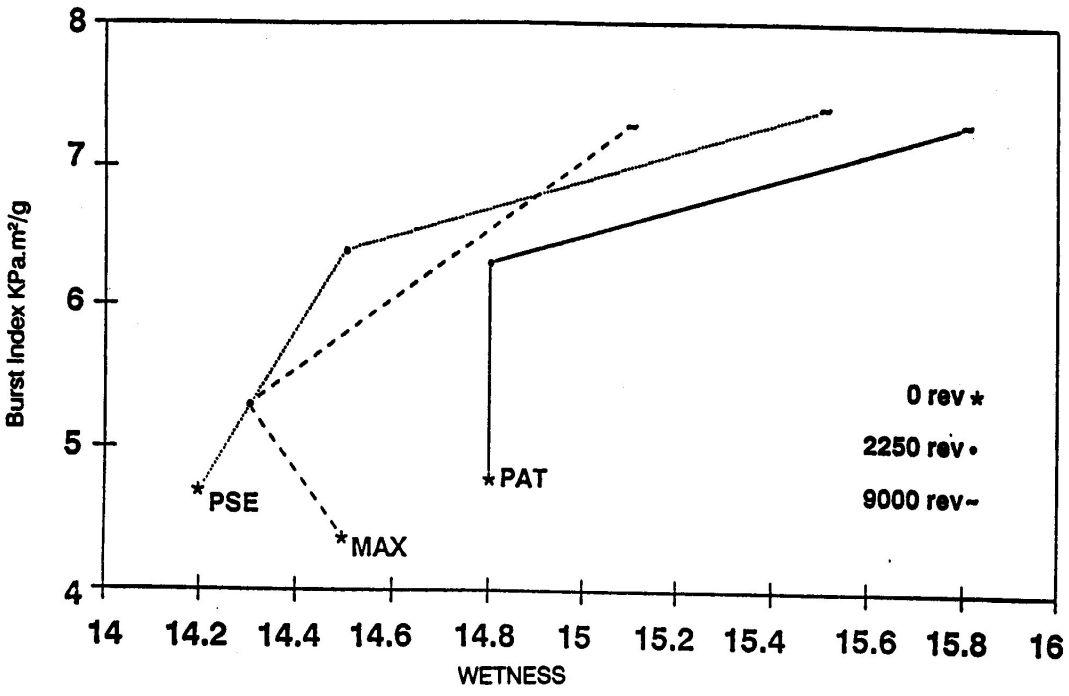

Figure 3 - Wetness versus burst index for pulp from the whole tree (mean values).

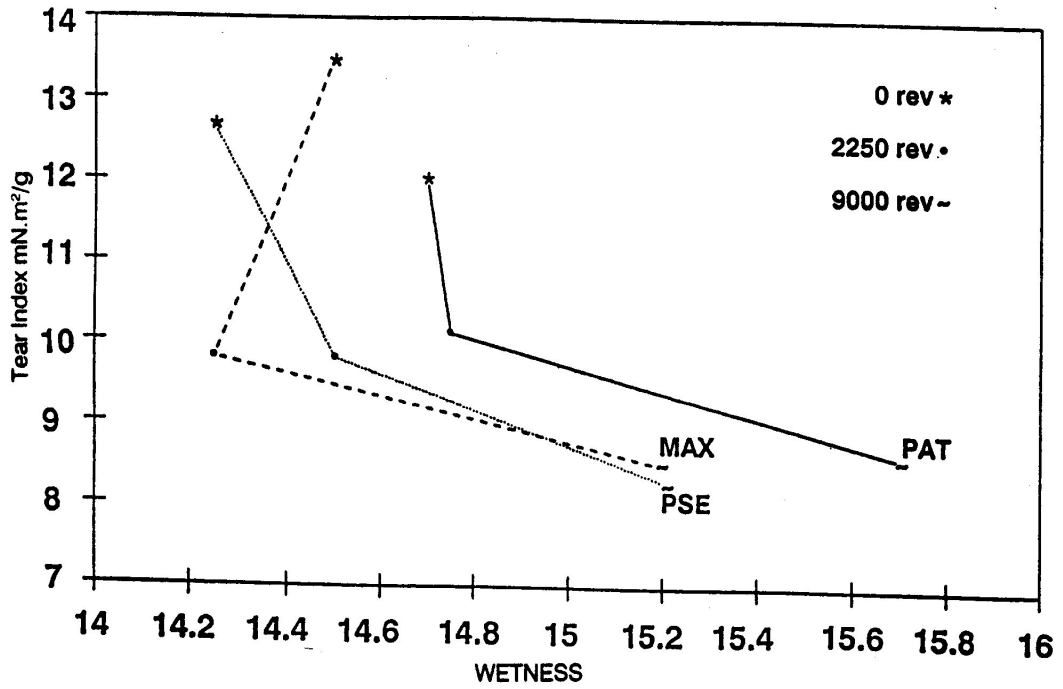

Figure 4 - Wetness versus tear index for pulp from the whole tree (mean values).

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