KRAFT PULP YIELDS OF EUCALYPT WOOD IN RELATION TO DEGREE OF DELIGNIFICATION AND WOOD SPECIFIC GRAVITY

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SUMMARY

The purpose of this investigation was the study of kraft pulping of *Eucalyptus* species and trying correlations between pulp yields and degree of delignification and pulp yields and wood specific gravity. The following conclusions could be drawn from the data analysis: a) there is an important influence of species on pulp yields at given degrees of delignification; b) it was found a linear pattern between total pulp yield and kappa number, as far as one species was considered as well as all together; c) the same pattern was found for reject content; d) the linear relationship was observed either for weight basis pulp yields and for volume basis pulp yields; e) no proportionality was observed between weight basis pulp yields and wood specific gravity; f) high correlation coefficients were noticed between volume basis pulp yields and wood specific gravity. So, one can assume that the morpholo-

gical variations on the woods of different species were the major factor to avoid proportionality between weight basis pulp yields and wood specific gravity. However, these differences were not strong enough to bring inter - ference on the close relationship between volume basis pulp yields and wood specific gravity.

RÉSUMÉ

Rendement en pâte kraft des bois d'Eucalyptus en fonction du indice de délignification et de la densité des bois.

Ces travaux avait pour but d'étudier la fabrication de pâte kraft des bois d'Eucalyptus et de tenter à determiner les correlations entre rendement en pâte kraft de bois d'Eucalyptus, l'indice de la cuisson et la densité des bois. A l'analyse des résultats, on a pu tirer les conclusions suivantes: a) Il existe une influence importante des variétés en rendement en pâte à indice donné kappa; b) on a trouvé un mode de variation lineaire entre le rendement totale et indice kappa, tant pour une varieté, comme pour les toutes;c) on a trouvé le même mode pour le degré de la rejection; d) on a observé cette rélation lineaire tant pour les rendements basés en poids comme basés en volume de pâte kraft des bois; e) on n'a pas observé la proporcionalité entre les rendements basés en poids et la densité des bois; f) on a trouvé coefficients élevés des correlations entre les rendements basés en volume et la densité des bois. En conclusion, on peut dire que les différences morphologiques en les bois de varietés differents étaient les facteurs principaux qui evitaient la proporcionalité entre les rendements basés en poids et la densité des bois.

Autrefois cettes différences n'avaient pas beaucoup des forces pour faire une interférence en rélation des rendements basés en volume et la densité des bois.

INTRODUCTION

There are today no doubts that eucalypts, among hardwoods, have reached a highly important situation as source of fibers for the pulp and paper industry. On the other hand, the successes which were acquired in kraft pulp industrial production and forest breeding, leading to denser and more uniform eucalypt wood, are well known in Brazil. However, because of the great number of species, and also, in reason of the ability of hybridation among many species, it is difficult to consider eucalypt as a well-defined pulpwood.

In recent years, a special emphasis has been given to the study of wood characteristics and pulp properties relationship. Among the parameters used to define wood quality, specific gravity ranks as the most important. Wood specific gravity is a compound characteristic which is affected by variations in cell wall thickness, cell type, cell diameter and the amount of non-structural materials such as extractives and tyloses. However the relation between wood specific gravity and fiber wall thickness is more pronounced for softwoods than for hardwoods. This is due to the large differences in the proportions of vessels and parenchyma cells.

The literature has shown several good articles which proved to happen a linear correlation between pulp yield and degree of delignification, as expressed either as permanganate number or kappa number.

Concerning to proporcionality between pulp yields and wood specific gravity, three different models may be found in the literature: *model 1*: linear positive proportionality between pulp yield per unit of digester and wood specific gravity; *model 2*: linear positive proportionality between weight basis pulp yields and wood specific gravity for just one species; *model 3*: same as model 2, but working with several wood species which have similar morphological characteristics, in most of the cases, of the same taxonomic genus.

There are some authors who suggest prudence in trying correlations between pulp properties and wood specific gravity. The reason for this is that wood specific gravity, although being well related to fiber wall thickness, has other factors which can influence it, mainly for *Eucalyptus spp.*

The basic objectives of this work were the following: a) to observe kraft pulp yields for the wood of the following species of *Eucalyptus*: *E. robusta*, *E. tereticornis*, *E. saligna*, *E. grandis*, *E. citriodora*, *E. propingua*, *E. maculata* and *E. paniculata*; b) to verify the pattern of variation of pulp

yield in relation to degree of delignification; c) to find out the implications of expressing pulp yields in two different bases: weight basis and volume basis; d) to verify the kind of relationship between pulp yields at given degrees of delignification and wood specific gravity.

EXPERIMENTAL METHODS

The woods used in this experiment came from 7 year-old homogeneous stands. Wood chip specific gravity was determined by the maximum moisture content method. Kraft process was used to pulp the woods. Seven cooks by species were performed, in a total of 56 cooks. Active alkali was variable in the range of 10 to 16% as Na_2O, and the other cooking conditions remained constant as follows: sulfidity = 25%; liquor to wood ratio = 4:1; maximum temperature = 170°C; time to maximum temperature = 2 hours; time at maximum temperature = 0,5 hour. The purpose was to obtain pulps with different degrees of delignification which was expressed as kappa number. Pulp yields (total, screened and rejects) were expressed in two ways: a) *weight basis*: ratio between o.d. pulp weight and o.d. wood weight, in percentage; b) *volume basis*: ratio between the o.d. weight of pulp (metric tons.) and the solid volume (cubic meter) of the cooked wood, in percentage.

When the pattern of variation of total pulp yields and reject contents were tested against kappa number, a highly linear proportionality was found. Linear equations of the type $Y = a + b X$ were stablished, where Y = total pulp yield or reject content, and, X = kappa number. Then, pulp yields at kappa numbers of 50, 40, 30 and 25 were calculated. Screened yields were calculated by subtracting.

Pulp yields obtained for each species at a given kappa number were related to wood specific gravities. The regression equation was of the type $Y = a + b X$ where Y = total pulp yield, screened pulp yield or reject content, and, X = wood specific gravity of the corresponding material.

RESULTS

Results are shown in tables 1, 2 and 3.

Table 1: Linear equations (values for a, b and r) relating weight basis pulp yield to kappa number.

SPECIES	WOOD SPECIFIC GRAVITY	TOTAL YIELD (%)			REJECT CONTENT (%)		
		a	b	r	a	b	r
E. robusta	0,452	44,21	0,17	0,99	- 9,48	0,48	0,98
E. tereticornis	0,512	44,88	0,14	0,93	- 9,40	0,48	0,97
E. saligna	0,562	45,16	0,20	0,96	- 5,12	0,28	0,96
E. grandis	0,575	43,25	0,17	0,99	- 6,90	0,31	0,97
E. citriodora	0,637	39,42	0,40	0,92	-12,63	0,69	0,98
E. propingua	0,643	40,75	0,20	0,96	- 8,86	0,38	0,98
E. maculata	0,647	43,76	0,15	0,96	- 6,25	0,37	0,95
E. paniculata	0,680	41,72	0,27	0,94	- 6,69	0,40	0,99
All woods together	-	43,73	0,18	0,85	- 7,55	0,40	0,92

Table 2: Linear equations (values for a, b and r) relating volume basis pulp yield to kappa number.

SPECIES	WOOD SPECIFIC GRAVITY	TOTAL YIELD (%)			REJECT CONTENT (%)		
		a	b	r	a	b	r
E. robusta	0,452	19,99	0,08	0,98	- 4,29	0,22	0,98
E. tereticornis	0,512	22,97	0,07	0,93	- 4,61	0,24	0,97
E. saligna	0,562	25,38	0,11	0,96	- 2,94	0,17	0,94
E. grandis	0,575	24,86	0,10	0,99	- 3,96	0,18	0,98
E. citriodora	0,637	25,10	0,25	0,92	- 8,07	0,44	0,98
E. propingua	0,643	26,23	0,13	0,96	- 5,66	0,24	0,98
E. maculata	0,647	28,28	0,10	0,96	- 4,04	0,24	0,95
E. paniculata	0,680	28,37	0,18	0,94	- 4,56	0,28	0,99
All woods together	-	26,52	0,09	0,43	- 4,11	0,23	0,91

The calculated yields at 50, 40, 30 and 25 kappa number were related to the specific gravity of the corresponding wood. The simple correlation coefficients (r) of the linear equations are presented in table 3.

Table 3 : Simple correlation coefficients (r) between pulp yields at a given kappa number and wood specific gravity.

YIELD	KAPPA NUMBER			
	50	40	30	25
Total, weight basis	0,22	0,11	0,10	-0,26
Total, volume basis	0,93	0,95	0,97	0,98
Screened, weight basis	0,14	0,01	-0,26	-0,48
Screened, volume basis	0,79	0,92	0,96	0,98
Rejects, weight basis	0,05	0,07	0,13	0,19
Rejects, volume basis	0,43	0,43	0,44	0,42

CONCLUSIONS

The following conclusions could be drawn from the data analysis: a) there is an important influence of species on pulp yields at given degrees of delignification. For weight basis pulp yields, the woods of *Eucalyptus saligna*, *E.grandis*, and *E. paniculata* led to higher screened yields and the woods of *E. citriodora*, *E. robusta*, *E. tereticornis*, and *E. paniculata*, higher reject contents.In volume basis, the highest screened pulp yields were obtained for *E. paniculata* and *E. saligna* woods and the lowest for *E. robusta* and *E. tereticornis*; b) it was found a linear pattern between total pulp yield and kappa number, as far as one species was considered as well as all together; c) the same pattern was found for reject content; d) the linear relationship was observed either for weight basis pulp yields as well for volume basis; e) no proportionality was observed between weight basis pulp yields and wood specific gravity; f) high correlation coefficients were noticed between volume basis pulp yields and wood specific gravity. So, one can assume that the morphological variations on the wood of different species were the major factor to avoid proportionality between weight basis pulp yields and wood specific gravity. However, these differences were not strong enough to bring interference on the close relation between volume basis pulp yields and wood specific gravity.