Variations in the Density and Fibre/Vessel Characteristics of Leucaena Leucocephala (Su-babul) and their effect on Printing Properties of Paper

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The paper gives an account of the variations in basic density and fibre vessel characteristics of *L leucocephala* grown in Pune, Siliguri and Rajabhatkhawa. The influence of basic density, fibre/vessel ratio, fibre shape factor and the Runkel ratio on printing properties (surface roughness and vessel pick number) and bonding strength (tensile index) of paper have been studied and discussed. It was found that density, fibre/vessel dimentions and their proportions varied appreciably with the locality of plantation. Direct correlations between basic density and the Runkel. ratio, fibre/vessel ratio and shape factor were observed. Both surface roughness and vessel pick number of paper (at 250 ml CSF) were not influenced by variation in the locality of plantation, whereas the tensile index varied markedly. This indicated that there was no effect of density. fibre/vessel ratio, the Runkel ratio and shape factor variations on paper surface roughness and vessel pick number, On the other hand, the bonding strength decreased with increasing density.

Although among hardwood Eucalyptus species heve been well accepted as paper making raw materials, yet other comparatively faster growing exotic species are being introduced in India for the same purpose. *Leucaena leucocephala* (Su-babul) a native of Maxico and Central America has attracted much attention as a plantations species. Being a good coppicer, it may be worked on short rotation of 2-3 years. The main determinants of pulping and paper making behaviour of hardwoods appear to be wood density and amount of extraneous materials or extractives present. In chemical or semi-chemical pulping while the extractives content mainly influence the chemical consumption and the pulp yield, the basic density of wood exerts its main influence on the structural and mechanical properties of paper or board. The basic density in turn is influenced by the ratio of fibre diameter to cell-wall thickness, the extractives content and distribution and the diameter and frequency of vessel elements.

In hardwoods fibres are long and narrow, the length being 25 to 50 times the outer diameter or width. Vessel elements are generally shorter than fibres but are many times wider. The characteristic of fibre to vessel and the characteristics of fibre and vessels vary from species to species. These difference are usually assessed in terms of age or tree size of which in turn is influenced by forestry factors such as rate of growth, response to soil, climate, biological attacks etc. Due to the variations in density, fibre/vessel characteristics and wood quality, wide differences are encountered in papermaking properties of hardwoods, even in the same genus.

It is the gross difference between the size of vessels and the fibres that contributes to the problems associated with the printing of papers that contain hardwood pulps in their furnish. The main problems is the picking of these vessels from the surface of paper during off-set lithographic printing.

Therefore in the light of above mentioned differences in physical properties of wood and its constituents, it becomes necessary to examine the potentiality of this new raw material for papermaking. The present paper deals with thc results of the studies carried out on the fibre/vessel characteristios of *L. leucocephala* grown in Pune (Maharashtra) Siliguri

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and Rajabhat akhawa (West Bengal) and their influence upon printing properties of paper.

EXPERIMENTAL

Wood samples of *L. leucocephala* grown in Pune, Siliguri, Rajabhatakhawa were used in this investigation.

The wood logs were converted into chips in a four knive waterous chipper. The chips were screened and air dried to obtain uniform sample; a sample consisting of chip size in the range of 0.64 to 2.50 cm in length and width having a thickness of 2-3 mm with moisture content of about 10% was considered adequate for these studies. The sample chips were stored in polythene bags for experimentation.

Density

The basic density of wood was determined as per IS specification 1708 (1969), oven dry weight/green volume basis.

Fibre/vessel dimensions

Fibre length and diameter wall thickness and vessel dimensions and frequency were measured (100 measurements each) from bleached pulp samples. The proportion of fibres, vessels rays and parenchyma cells were determined from sections taken out from wood discs.

Pulp preparation

Kraft pulps were prepared by cooking wood chips under the following conditions: Chip charge 400 g (o.d.); total active alkali as Na_2O 17% chip to liquor ratio (including chip moisture) 1:3:5; cooking temperature 170°C, cooking schedule-room temp to 100°C, 0.5 hr; 100-170°C, 1.5 hr; at 170°, 1.0 hr. The kappa number of pulps thus obtained was 26+1. All the three pulps were bleached using CEH sequence under the following constant conditions:

Chlorination—Chlorine charge 5.0%, consistency 3.0%; temp. 30°C, time 1.0 hr.

Alkali extraction:—Caustic soda 2.0%, consistency 8.0%; temperature 70°C; time 2.0 hr.

Hypochl rite treatment:—Available chlorine 2.0%; consistency 8.0%; temperature 45°C; time 2.0 hr. All the percentage expressed above are on oven dry pulp. In case where the brightness developed was less than 72±1 a second hypochlorite treatment was given under identical conditions. Only pulp from Siliguri wood required second hypo chlorite treatment.

Pulp Evaluation

The yield of bleached pulp was determined in usual manner. It was found to be 45.5% in all the three cases. For physical properties evaluation, the pulps were beaten in PFI mill to different degreess of freeness according to ISO standard 5264 by charging 30 g o.d. pulp at 10% consistency, 177 N/cm beating pressure and 6.0 meter/relative speed. Handsheets of 60±2 gsm were made on standard British sheet making machine. The sheets were pressed and air dried using standard procedure. The testing of hand sheets for various printing properties was carried out after conditioning the sheets at 65±2% RH and 27±1°C. The tests on strength properties were performed according to ISO standards.

Printability/Vessel pick

The method used for vessel pick number was similar to that employed by Colley[1], with the modification of using higher printing speed (60 cm/s) instead of 30 cm/s, so as to compensate the effect of different conditions used in this investigation for conditioning the paper sample as compared to 65% RH ard 20°C employed by him. To determine the vessel pick number IGT printability tester AIC2 was used. Strips of 25 mm width and approximately 150 mm length were cut and printed on glazed side of handsheet using the following printing conditions.

Type of ink-black tacky non-drying IGT collie ink.
Amount of ink-equivalent to ink layer of 10microns,
Blanket–IGT litho blanket shore hardness 90
Printing pressure–490 N
Dise–2 cm (aluminium)

Immediately after printing, the wet print surface was brushed twice in the direction of print to lift up the vessels dislodged during printing of the test strip. A set area of 2000 mm^2 was marked on the printed strip and number of white spots greater than 120/μm width were counted.

Surface roughness

Surface roughness of the glazed side of handsheets was measured on a Parker Print Surf Roughness tester. Tests were carried out under off-set conditions. Off-set blanket was used as a blacking and clamping pressure was set at 980 kPa which corresponds roughly to the off-set printing.

RESULTS AND DISCUSSION

Density and Fibre/Vessel characteristics

The data on wood density and fibre and vessel dimensions are recorded in Table-1. The proportion of tissues and fibre characteristics are given in Table-2. It will be seen from these data that the basic density of the three samples of *L. leucocephala* wood varied with the place of plantation in the following order : Pune Siliguri Rajahatkhawa. The values ranged between 0.469 to 0.501.

TABLE—1

WOOD DENSITY AND FIBRE AND VESSEL DIMENSIONS OF L. LEUCOCEPHALA

Sample locality	Basic wood density g/cm³	Fibre dia (d)	Average fibre and vessel diamensions (mm)				
			lumen dia (l)	Wall thickness ×2 (2w)	Fibre length	Vessel dia	Vessel length
Pune	0.501	23.33	12.90	10.45	963.56	157 39	377.57
Siliguri	0.476	24.76	14.33	10.41	1018.06	163.94	333.10
Rajabhatkhawa	0.469	24:17	15.16	9.01	982.31	173 53	382.37

TABLL-2

PROPORTION OF TISSUES AND FIBRE CHARACTERICS

Sample locality	Proportion of tissues, %				Fibre characteristics	
	Fibres	Vessels	Parenchyma	Rays	Runkel ratio 2w/l	Shape factor $(d_2-l^2)/(d^2+l^2)$
Pune	64.5	8.5	9	18	0.81	0 532
Siliguri	60 0	8 0	17	15	0 72	0.498
Rajabhatkheawa	58 0	9.0	16	17	0 59	0.435

A perusal of data on fibre/vessel characteristics revealed that there is not much variation in fibre diameter, vessel length and wall thickness of the three samples of *L. leucocephala* whereas appreciable variation in lumen diameter, fibre length and vessel diameter is encountered. The fibre diameter (d), wall thickness (2W) and vessel length, respectively, ranged in between 23.32 to 24.76μm, 9.01 to 10.41/μm and 333 10 to 382.37/μm. On the other hand lumen diameter (1), fibre length and vessel diameter ranged between 12.90 to 15.16/μm, 982.31 to 1018.06/μm and 157.39 to 173.53/μm, respectively. Further, the data on proportion of tissues indicated that the percentage of fibre varied appreciably with locality ranging from 58% for Rajabhatkhawa plantation to 64.5% for Pune plantation. The percentage of vessels did not vary to any appreciable extent (9–10%). The perenchyma cell percentage varied from 9 for Pune plantaion to 17 for Siliguri. The overall fibre characteristics as defined by the Runkel ratio (2w/l) and the shape factor $(d^2-L^2)/(d^2+L^2)$ exhibited wide variations among the three samples of different places.

The Runkel Ratio in Rajabhatkhawa plantation was lowest (0.59) and it was highest in case of Pune plantation. The shape factor was also lowest in case of Rajabhatkhawa plantation (0.435) and hightest in case of pune plantation (0.532)

It has been observed that the basic density, the Runkel raito, the fibre/vessel ratio and the factor are interrelated. A plot of these data of *L. leucecephala* samples Fig. 1 to 3, showed that the shape factor, the

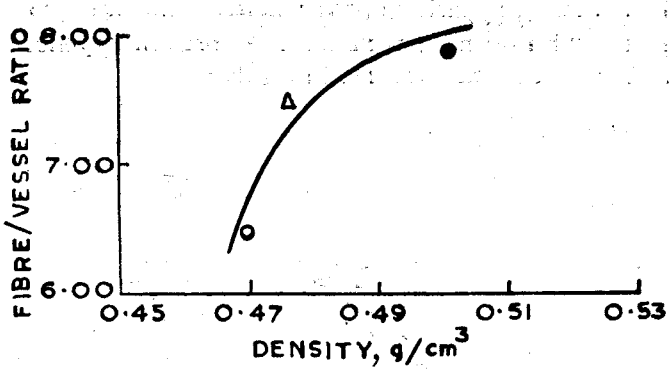


FIG. 1 — DENSITY VS. FIBRE/VESSEL RATIO.

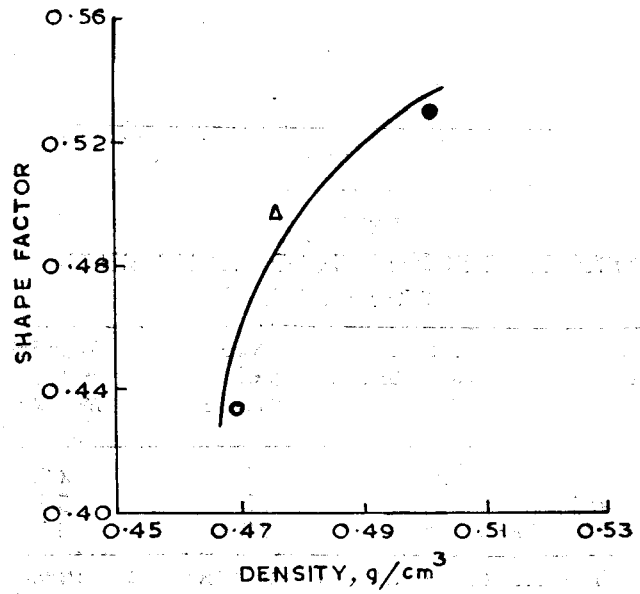
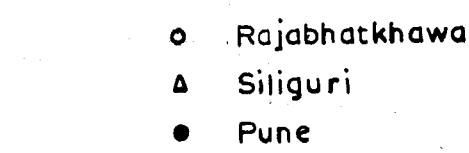


FIG. 2 — DENSITY VS. SHAPE FACTOR.

Runkel ratio and the fibre/vessel ratio increased with density. The basic density of wood is directly influenced by the vessel content and fibre diameter to wall thickness ratio. It is directly related to fibre collapasibility/conformability, the degree of fibre collapse and bonded area, and which in turn impart their direct influence on surface and to other properties of paper. The fibres of low density wood are ribbon like and flexible, whereas those of high density, wood are cylindrical and rigid. Due to these characteristics low density wood are preferred Thus it will be seen that the measurements on the wood properties (i. e. density and fibre/vessel characteristics) are of great value in assessing the paper properties in general and printing properties in particular.

Wood characteristics versus printing properties

The influence of varitions in wood characteristics



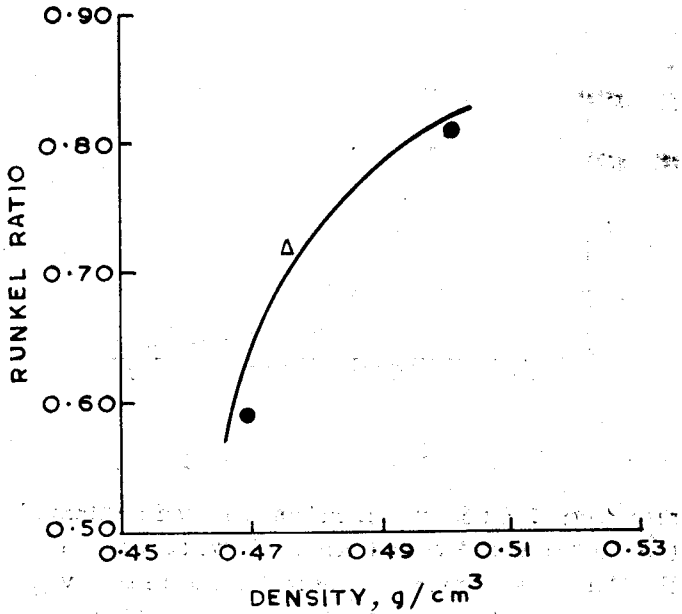


FIG. 3 — DENSITY VS. RUNKEL RATIO.

on printing properties of paper could be examined by plotting paper surface roughness and vessel pick number against each characetristic. Fig. 4 and 5 show the changes in surface roughness and vessel pick number with degree of beating (freeness of pulp)

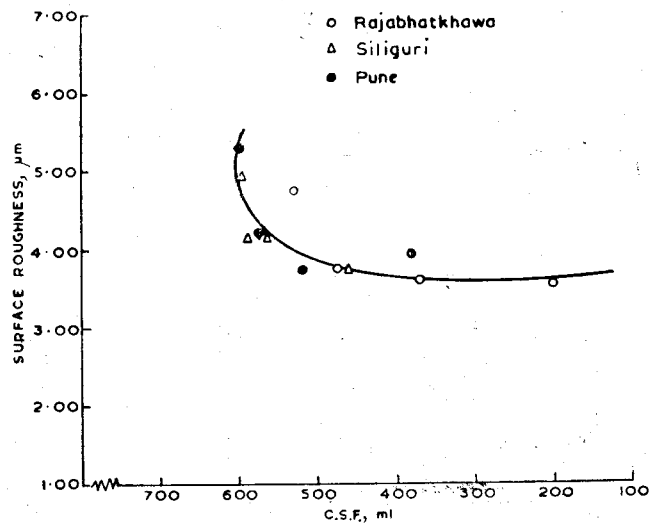


FIG. 4 — C.S.F. VS. SURFACE ROUGHNESS

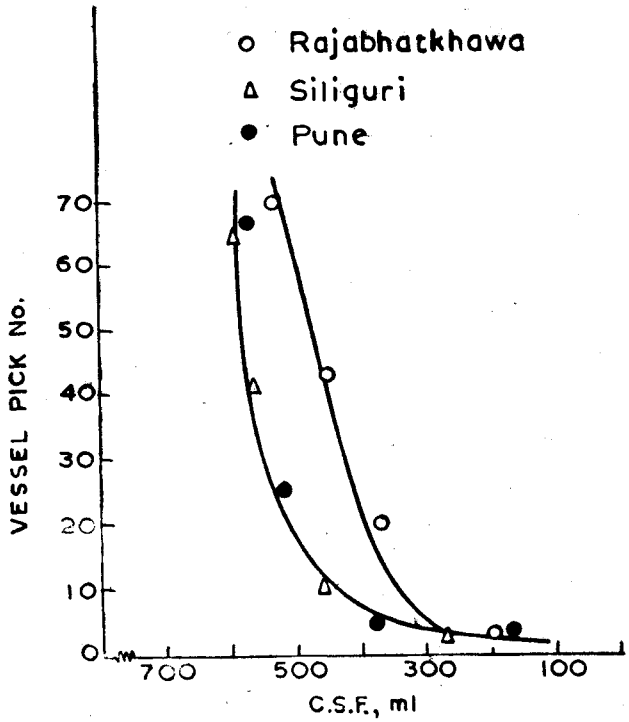


FIG. 5—C.S.F. VS. VESSEL PICK No.

respectively. Fig 6 gives the change in tensile strength (bonding strength) with freeness. It will be seen from Fig. 4 that the change in surface roughness value with beating (decreasing freeness) is almost same in case of all the three samples of *L. leucocephala*. Fig 5 indicates a change in vessel pic number with decreasing freeness. The graph shows that the behaviour of decrease in vessel pick number with decreasing freeness is almost similar for the three semples studied. The change in tensile strength with decreasing freeness is however, found to differ with place of plantation,

Fig. 6. For comparision of the changes in these properties with freeness, the data have been interpolated at 250 ml CSF and recorded in Table 3.

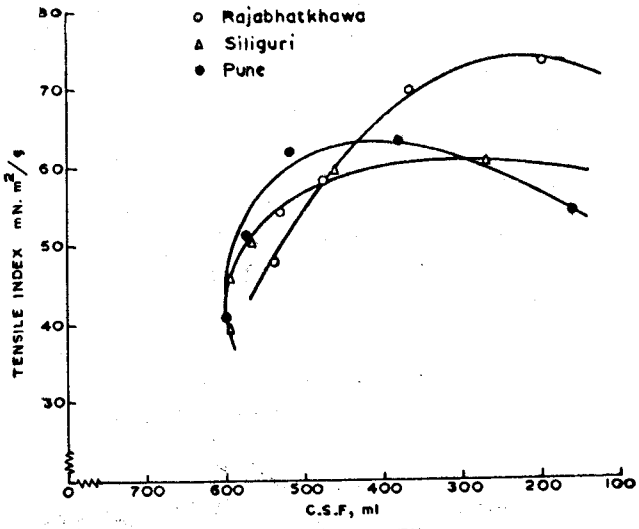


FIG. 6—C.S.F. VS. TENSILE INDEX

TABLE—3

PRINTING PROPERTIES OF HAND SHEETS AT 250 ml. C.S.F

Sample locality	Surface roughness, /μm	Vessel pick number	Tensile index m-Nm²/g
Pune	3.05	3.0	68.0
Siliguri	3.65	3.0	75 5
Rajabhatkhawa	3.65	3.0	83.5

The effect of locality of plantation on surface roughness, vessel pick number and tensile index of paper at the interpolated value of 250 ml CSF. is represented in the bar diagram, (Fig. 7). It will be

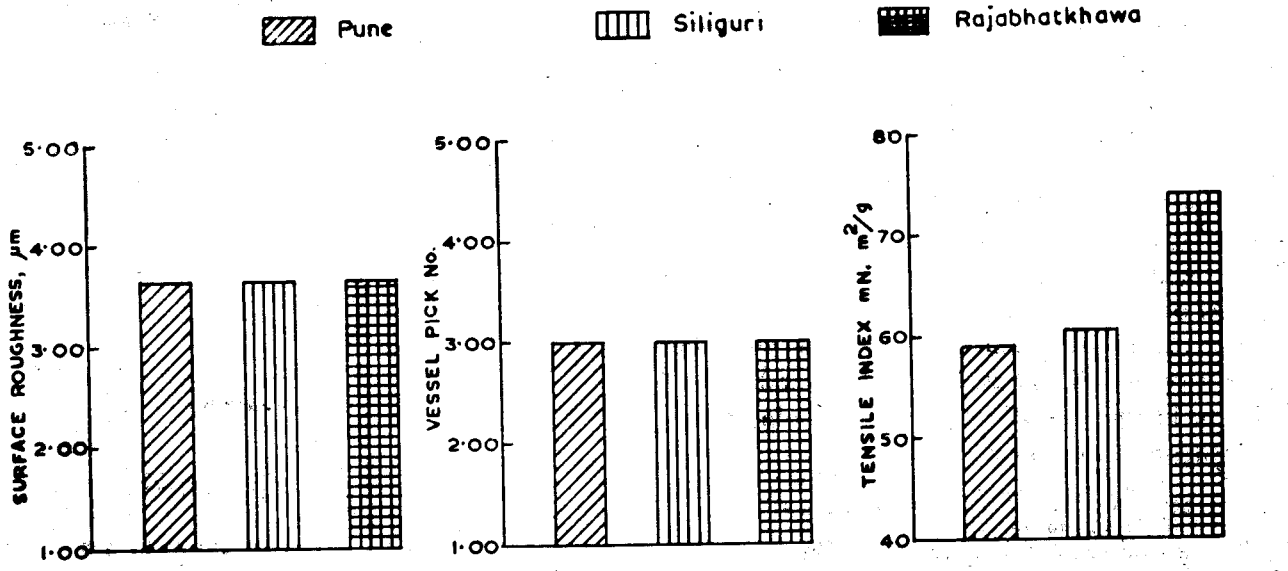


FIG. 7—EFFECT OF LOCALITY ON PRINTING AND BONDING PROPERTIES (at 250 ml C.S.F.)

seen that both surface roughness and vessel pick number of paper from all the three samples of *L, leucecephala* did not vary with the place of plantation, wheress the tensile index varied markedly; the order being Rajabhatkhawa Siliguri Pune. This indicated the Rajabhatkhawa sample is better than the other two, as far as bonding strength of paper is concerned; the samples from Siliguri and Pune being fairly comparable with each other. Thus it can be concluded that there is little influence of density, the Runkel ratio, fibre/vessel ratio and the shape factor on surface roughness and vessel pick number of paper in case of these three samples of *L. leucocephala*, because the plantation locality did not exhibit any effect on the value interpolated at 250 ml CSF level which is usually kept for papermaking. On the other hand there appears to be marked influence of density, fibre/vessel characteristics on bonding strength, as the tensile index varied appreciably with plantation locality. The variation in tensile index with density is represented in Fig. 8. It will be seen that bonding strength as represented by tensile index decreased with increasing density. As basic density is directly related to fibre/vessel ratio, shape factor and the Runkel ratio, the influence of these fibre/vessel characteristics on bonding strength of paper can be visualised easily. The properties (as represented by surface roughness and vessel pick number at 250 ml CSF) of paper from these three samples of *L. leucocephala* are comparable with each other.

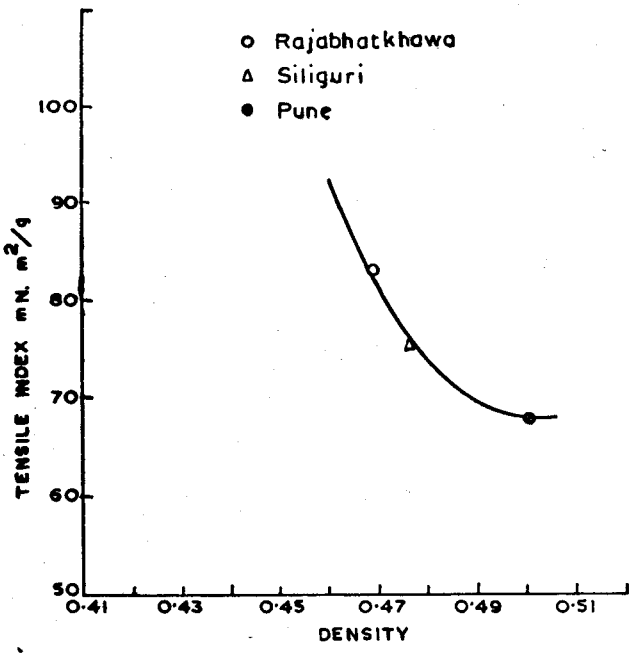


FIG. 8—EFFECT OF DENSITY ON TENSILE INDEX (at 250 ml CSF)

REFERENCE

Colley. J., Paper Technology, 14 (5), 293 (1973).