Characteristics Variations of Chemical Composition by Aging of Fibrous Raw Material— Leucaena Leucocephala

Agarwal, Anupam*, Garg, S.C.*, and Raghunath V.**

ABSTRACT

The Chemical composition of a fibrous raw material is an important basic consideration in determining its suitability for conversion to pulp or other useful end products. *Leueaena leucocophola* has shown great potentiality for pulp manufacture. Hence it was selected for experiments. Changes in physical and chemical properties of the wood of 3 years, 4 years, 5 years and 6 years old trees have been studied. The results favour choice of the wood of 4 years old trees due to its low basic density, high holocellulose content and low lignin percentage and lesser solubility in water and organic solvents,

Physical and Chemical nature of the wood species needs special attention while discussing its pulpability. Data on the chemical composition of the wood serve as a guide in determining the uses for which it may be best suited. From the paper making point of view, wood species with high holocellulose and more pentosans contents but low in lignin, extractives, ash and silica contents, would be the most desirable pulping material.

The time has now come, when there is an urgent need for an approach to man made plantation for the survival of pulp and paper industry. Before going in for a large scale plantation, suitability of the proposed species for the particular use has to be thoroughly examined. For example, if the plantation is to be taken for pulp and paper industry, the choice of species to be raised will naturally fall on such woods which are fast growing, easy to debark and chip and yield good quality pulp in high percentage. Also it is to be seen that it could be raised and with certainty in the economically viable tracts, with high survival rate. To avoid repeated planting cost, good coppicers having vigour to coppice for several rotations is to be preferred. Crop harvesting cycle is to be determined by adopting the best mix of maximum volume of wood available at a given period, and its optimum suitability for pulping at that stage. Till now the industry was getting raw materials from the natural forests. It had to depend on whatever was available without consideration of the age and other important factors directly affecting the economic of operatian. This always caused a variation in physical and chemical composition in the species which directly affected the pulping process and the cost. It has often been observed that inspite of identical conditions of cooking there tends to be lot of difference in the quality of pulp. This difference can partly be attributed to the variation in the physical and chemical characteristics of the raw material. These characteristics depend on many factors, such as tree's age, soil conditions, planting method, rainfall of the area, etc.

These characteristics need to be investigated and and the most suitable conditions created to get the best out of any plantation. Keeping these factors in view the changes in the physical and chemical nature of *Leucaena leucocephala*, a promising *Leauminoceas* species for pulp and paper industry have been studied.

RESULTS AND DISCUSSION

Basic density and bulk density are helpful in deter-

*Department of Chemistry, Dr. Harisingh Gour Vishvavidyalaya, Sagar, M P, 470003.
**The National Newsprint and Paper Mills Limited, Nepanagar, M.P. 450221,

mining the cooking chemical concentration and wood to liquor ratio requirement. Bulk density and basic density of *Leucaena leucocephala,* increase with the age, and are nearly the same as of other hardwoods and bambo. These densities are seen to increase which may be due to formation of heart wood with the age. The results show that there is a reduction in the bark percentage of *Leucaena leucocephala* from 7,9% to 6.2% at the there years and 6 years of age respectively.

The holocellulose content is a qualitative indication of fibrous raw material influencing consideration of its suitability for making pulp and paper. Results recorded in table 1 indicate that percentage of holocellulose is slightly higher in the younger wood of this species and it is higher than holocellulose of other conventional raw materials.

Ash represents the non-volatile, non-combustible and inorganic portion of the raw material. The ash content ranged from 0.80% for 3 years old wood to 0.72% for 6 years old wood. When compared to other raw materials the ash content is low.

Extractives are the components in the ligno-cellulosic material which can be removed by water or organic solvents. Materials with high extractive content are generally less desirable for pulping as they give lower pulp yields and consume more pulping chemical than those with low extractives.

The cold and hot water extractives include organic salts, sugars, gums, pectin like material, tannins and pigments. Water solubility of the *Leucaena leucocephala* are low in comparison to other species and it slightly increases with the age.

The alcohol-benzene extractives contain waxes, fats, resins and some other insoluble components. Alcohol benzene solubility of *Leucaena leucocephala* increases marginally with aging and it is lower than other species.

The solubility in 1% caustic soda is an indication of the resistance of wood to solution by hot dilute alkali. This also determines the degree of fungal decay in a material. As a fibrous material decays, the caustic solubility increases, resulting in a corresponding decrease in pulp yield. Leucaena leucocephala has comparatively low 1% caustic solubility and it increases as the tree grows older.

Lignin is the non-fibrous cementing substance which gives strength and rigidity to the cell walls of the fibres. From pulp manufacturing point of view, lignin is considered to be undesirable. Materials with high lignin content are less desirable and they would require a relatively high chemical consumption in pulp production. Of the wood samples analysed, lignin of Leucaena leucocephala has nearly the same value as those of other woods. but the lignin content increases prominently with the growth of the tree.

Bark in this wood also contains higher percentage of solubles and low content of holocellulose and lignin. While the solubilities and lignin increase with the age, holocellulose decrease.

Recent studies on co-relation of physical dimensions of fibre with properties of pulp reveal the interesting fact that not only the fibre length but the width of the fibre, cell wall thickness, lumen width and fibre quality or intrinsic fibre strength) are also important in determining the quality of pulp. Fibre wall thickness is important to contribute to the freeness of the pulp – the ratio of lumen diameter to fibre diameter to fibre diameter has also importance in affecting sheet density, tensile and bursting strengths.

The favourable effects of increased L/D ratio which in turn helps to increase fibre to fibre contact in the pulp.

The average fibre length increases with aging of the tree th a limited extent but there is practically no difference in the slenderness ratio (L/D).

CONCLUSIONS

1. Wood of 4 years of age is seen to be most suitable for pulp manufacture because of its low basic density. Density increases with the age subsequently necessitating higher concentration of chemicals and longer time for proper penetration and cooking.

2. Lower lignin, lower solubility and higher holocellulose favour this age for getting higher yields.

3. With the aging due to the increase in heartwood content, lignin and solubilities increase, resulting in darker shade of the pulp. Therefore, the crop cycle may be limited to four years where the above mentioned parameters are within optimum range. Also the volume of wood available is favourably comparable.

4. Fibre dimensions are satisfactory for good burst and tensile index but the tear index may be low due to less slenderness ratio (L/D).

5 The use of wood of specified age will help in controlling the process variables and also in getting the pulp of desired quality.

EXPERIMENTAL

Leucaena leucocephala (Subabul) wood logs of four different age groups of 3 years, 4 years, 5 years and 6 years old trees were obtained from the Bhartiya Agro Industries Foundation, Urli Kanchan, Dist. Pune (Maharashtra) for experimental purposes. The bark was removed manually. The chips were prepared in the Papco chippers of the Nepamills. The chips were screened and the chips passing through 20 mm hole diameter and those retained on 5mm hole diameter were collected for studies. Wood dust was prepared from these chips in the laboratory grinder and the dust passing through 40 mesh and retained on 60 mesh was collected and used for analysis. The analysis wes carried out as per TAPPI standard methods except for holocellulose which was determined by sodium chlorite method of Wise et al[1,2,3].

Physico-chemical data on *Leucaena leucocephala* of different ages are furnished in table 1. For comparison, similar data on bamboo, mixed hardwoods, straw and other fibrous raw material are shown in table 2.

The same experiments were carried out for bark of the wood of different age trees and results are recorded in table 3. Fibre length, diameter, wall thickness and lumen diameter of the wood as observed are recorded in table 4.

TABLE—1

PHYSICAL DATA ON LEUCAENA LEUCOCEPHALA WOOD OF DIFFERENT AGES.

S. No.	Particulars	3 years	4 years	5 years	6 years
1.	Basic density of wood, g/cm³	0.51	0.54	0.58	0.60
2.	Bulk density of chips, g/cm³	0.199	0.212	0.218	0 220
3.	Bark percentage	7.90	7 20	6.90	6 70
	PROXIMATE ANALYSIS				
4.	Ash %	0.80	0.77	0.76	0.72
5.	Cold Water solubility %	1.01	1.08	1.11	1.12
6.	Hot water solubility	2.10	2 35	3.00	3.18
7.	1% NaOH solubility %	13.71	14.12	16.21	16 92
8.	Alcohol-Benzene Solubility %	1.80	1.78	1.84	2 11
9.	Lignin %	22.37	23.14	25.64	25.96
10.	Holocellulese %	73.41	72.56	69 66	68.92
11.	Alpha cellulose %	43.75	43.49	42.38	42 29
12.	Beta cellulose %	13.11	12.43	11.48	11.59
13.	Gamma Cellulose %	17.53	17.44	17.12	17.22

* All percentages are expressed on O.D. wood bassis.

TABLE—2

PHYSICAL DATA OF SOME OTHER RAW MATERIALS*

Raw Material	Basic density of Chips g/cm³	Ash	Hot water solubility %	1% NaOH solubility %	Alcohol Benzene solubility %	Lignin %	Hollocellulose %	Pentosans %
Bamboo[4]	0.54	3.07	5.93	24.00	2.31	28.00	65 90	19.56
Salai	0.50	2.27	14.23	24.40	3.91	25.70	50.70	19.29
Eucalyptus	0.58	—	6.70	19.45	2.20	25.52	70.17	—
Spruce	—	0.30	5.20	—	2.40	28.60	—	12.30
Teak	—	1.40	—	—	—	30.50	50 00	12.30
Coniferous wood[5]	—	1.00	—	—	—	26.30	—	12.03
Sabai grass[6]	—	6.00	9.50	39.70	4.10	22.00	66.40	23.90
Bagasse[5]	—	1.80	3.70	27 80	1.90	22.50	70.40	26.90
Kenaf[4]	0.30	2.40	7.90	26.80	1.86	21.50	72.00	—
Wheat Straw[5]	—	8.50	7.90	—	3.20	20.33	67.00	28 90
Rice Straw[5]	—	15.10	9.90	44.70	5.10	16.60	62.60	27 70
Reeds[7]	—	3.46	7.90	34.20	1.94	18.10	79.80	—
Sesbenia aculata[8]	0.35	0.80	6.10	25.00	1.90	21.90	74.60	—
Su-Babul of 4 years age	0.54	0.77	2.35	14.12	1.78	23.14	72.56	—

* All the percentages are expressed on O.D. wood basis.

TABLE-3

PROXIMATE ANALYSIS OF BARK OF LEUCAENA LEUCOCEPHALA OF DIFFERENT AGES

S.No	Particulars	3 years	4 years	5 years	6 years
1.	Hot water solubility%	13.52	14.41	15.28	16.03
2.	1% NaOH solubility%	42 13	42.99	46.16	48.94
3.	Alcohol benzene solubility%	5.64	6.43	5.96	7.01
4.	Lignin%	18 83	19.43	21 11	21.79
5.	Holocellulose%	58.98	57.49	56.12	54.63

* All the pereentages are expressed on O.D. wood basis.

TABLE-4

FIBRE DIMENSIONS OF LEUCAENA LEUCOCEPHALA WOOD OF DIFFERENT AGES

S. No.	Particulars	Average Fibre length mm	Fibre diameter mm	Slenderness ratio (L/D)	Lumen width mm	Cellwall thickness mm
1.	3 years	1.13	0.0209	54	—	—
2.	4 years	1.16	0.0210	55	—	—
3.	5 years	1.17	0.0217	54	—	—
4.	6 years	1.19	0.0224	53	0.0144	0.004

TABLE-5

FIBRE DIMENSIONS OF SOME FIBROUS RAW MATERIALS

S. No	Raw Material	Material texture	Average length mm	Average diameter mm	Slender-ratio (L/D)
1.	Bamboo	Dense	1.65	0.012	137
2.	Salai	Dense	0.88	0.024	37
3.	Eucalyptus	Dense	0.79	0.018	43
4.	Spruce[5]	Dense	3.5	0.05	70
5.	Pine[5]	Dense	3.0	0.05	60
6.	Sisal		2.7	0 019	142
7.	Sabai grass[5]	Open	2.08	0 009	231
8.	Bagasse[6]	Open	1.4	0 018	78
9.	Kenaf[6]	Open	1.8	0.032	56
10.	Wheat Straw[6]	Open	1.10	0.012	91
11.	Rice straw[6]	Open	1.13	0.016	70
12.	Jute sticks[9]	Open	2	0.022	91
13.	Cotton[9]	Open	18	0.020	900
14.	Water Hyacinth	Open	1.604	0.055	29
15.	Sesbania Aculata[8]	Open	0.9	0.010	90
16.	Subabul of 4 years age	Dense	1.16	0.0210	55

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