EFFECT OF AGE, LOCALITY AND SAMPLING POSITION ON CHEMICAL COMPOSITION OF EUCALYPTUS CAMALDULENSIS DEHN. WOOD

by

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Abstract

Variability in wood chemical composition with age, locality and sampling position of Eucalyptus camaldulensis wood grown at Khipro and Chichawatni were studied. No variation in chemical composition could be found with respect to position of sample in the tree. However, variation among the individual trees is larger than that within a tree. Minor variations in chemical composition of Eucalyptus wood were also noted due to age of trees and locality of their growth.

INTRODUCTION

Pakistan is deficient in woody raw material for pulp and paper manufacture. Pulp and paper products worth Rs. 2,164 million are annually imported to meet local needs. Fast growing hardwood species like Eucalyptus and Poplar could play an important role for supplying raw material for local paper industry. Among all the Eucalyptus species so far introduced in Pakistan, E. camaldulensis has proved successful under a variety of ecological conditions of Pakistan (Siddiqui et.al. 1984). Therefore, this is one of the major species of all afforestation programmes in the country.

At present Eucalyptus wood is only used as fuelwood and in rural construction and has no considerable commercial importance. Government as well as private sectors are planning for its industrial utilization as raw material for local pulp and paper industry, which at present is totally based on non-woody raw materials like wheat straw, bagasse and grasses. Utilization of Eucalyptus and poplars for pulp and paper will not only increase quantity and quality of locally manufactured paper, but also extend the raw material base for this industry.

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Chemical composition of wood has a strong influence on pulping processes and economics of paper manufacturing, therefore chemical analysis of wood is a pre-requisite to determine its suitability for paper production. Locality and age of trees do affect the chemical composition of wood (Higgins, 1978 and Singh et al, 1986). No systematic studies have been carried out so far on the chemical composition of locally grown Eucalyptus wood in Pakistan. The present study of the chemical composition of Eucalyptus wood in relation to age, site and sampling position in the tree is therefore, the first of its kind.

MATERIAL AND METHOD

Wood samples from six trees each representing three age groups (4,6,8 years) were selected from two different localities of Khipro (Sindh) and Chichawatni (Punjab) forest plantations in 1988.

First two logs from the butt end each of six feet length from each tree were taken for the determination of chemical composition. After debarking, chipping was carried out by using two knife Appleton chipper. The chips were classified in a STAFFI Classifier. N_3 fraction of the chips was used for sample preparation and chips were refined in Wiley Mill. Samples for chemical analysis were prepared according to TAPPI Standard Method T 257-os-76. For the determination of hollocellulose, alphacellulose, kurschner cellulose, alcohol/benzene extracted samples were used. For lignin samples were extracted with 0.1M NaOH solution. The chemical composition of wood was determined by the following TAPPI standard procedures:

1. Ash TAPPI T- 211
2. Cold water solubles TAPPI T- 207-om- 71
3. Hot water solubles TAPPI T- 207-om- 71
4. 1 % Alkali solubility TAPPI T- 212
5. Lignin TAPPI T- 222-os- 74
6. Hollocellulose (Wise, et al, 1946 and Erickson, 1962)
7. Alphacellulose (Siddiqui, 1976)
8. Kurschner Cellulose (Kurschner and Popik, 1962)

For above chemical analysis four determinations of each chemical constituent were made for wood samples representing age, locality and sampling position. Their mean values were computed and reported as the percentage of oven dry wood weight.

RESULTS AND DISCUSSION

Chemical composition of Eucalyptus

The average values of major chemical components of Eucalyptus camaldulensis wood of 4, 6, 8 years age grown at Khipro and Chichawatni are given in Table 1

Table 1. Average chemical composition of E. camaldulensis wood grown at Khipro and Chichawatni

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Age yrs	Ash %	C.W. %	H.W. %	A/B %	1% A.S. %	Lignin %	H-C %	-C %	K-C %
4	0.66	2.48	3.88	2.32	10.52	23.34	77.20	45.50	49.15
6	0.61	5.34	8.55	2.61	16.09	26.42	73.63	43.30	45.11
8	0.46	5.45	8.47	2.98	17.50	27.82	71.93	42.71	45.80
Ave	0.58	4.42	6.97	2.63	14.70	25.86	74.25	43.83	46.18

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(C.W: Cold water extractives; A/B: Alcohol/Benzene extractives; H.W: Hot water extractives; 1% Alkali solubility; H.C: Hollo-Cellulose; o<-Cell: Alphacellulose; K-C: Kurschner Cellulose)

Ash Contents

As shown in Table 1, the average ash content of Eucalyptus wood is 0.58 percent (ranging from 0.46 to 0.66) rising to 0.66 percent at the age of four years. In this connection it has been observed that inorganic contents of the wood may increase due to soil condition or presence of wetwood (Shigo and Hills, 1972). A large scale resorption of Potassium and Phosphorus may occur when eucalypt sapwood is transformed into heartwood.

Cold and Hot water solubles

The samples of Eucalyptus wood have 4.4 percent solubility in cold water and 7.0 percent in hot water. Range for cold water

solubles is from 2.5 to 5.4 percent, while hot water solubles ranged from 3.9 to 8.5 percent. Hot water solubles mainly include tannins, kinos, coloring matters, sugars, free acids and free mineral matters.

Alcohol/Benzene extractive

Average alcohol/benzene extractive of eucalyptus are found to be 2.63 percent with the range of 2.32 to 2.98 percent. The alcohol/benzene extract of eucalypts contains polyphenols, mainly in the polymerized form and very occasionally other compounds. The extractive include ellagic acid, gallic acid and ellagitannins, gallotannins, flavonoids and their polymers.

Alkali solubility

Average solubility of wood samples in one percent Sodium hydroxide solution is 14.7 percent having a range of 10.5 to 17.5 percent. Hot alkali solution extract contains low molecular weight carbohydrates, consisting mainly of hemicelluloses and degraded cellulose in wood.

Lignin

Lignin content of Eucalyptus wood ranged from 23.3 percent to 27.8 percent with mean value of 25.9 percent. Lignin of eucalypts are of syringyl-guaiacyl type with minor variations in composition within the tree and between species (Kawamura and Bland, 1967; Bland and Menshun, 1970).

Hollocelluloses and Cellulose

Eucalyptus wood samples contained 71.4 to 77.2 percent hollocellulose and 42.7 to 45.5 percent alphacellulose. Average content of hollocellulose was 74.2 percent, while average content of alphacellulose was 43.8 percent. Kurschner cellulose of E. camaldulensis wood were in the range of 45.3 to 49.1 percent.

Major chemical constituents of Eucalyptus wood are within the acceptable range for hardwood species used for pulp and paper manufacture and the results of this investigation are in accordance with the earlier studies reported by Queiroz (1971), Barrichelo and Brito (1976) and Bosia (1963).

Effect of Age on Chemical Composition

As shown in Table 1 and Figure 1, it is evident that age of the tree had an effect on chemical composition of Eucalyptus wood.

Ash contents of wood decreased from 0.66 to 0.46 percent with the increase in the age of trees from four to eight years. Detailed studies are needed to find out the percentage of various elements in the ash contents of Eucalyptus wood. The results may help in finding out a correlation between level of micronutrient in ash and growth rate of eucalyptus in a particular area.

As regards the presence of various elements in ash contents, manganese and iron are of a high concern because these elements cause discoloration to the pulp due to reaction with extractives (Watson and Cohen; 1969). Ash contents are also important for the production of dissolving pulp from Eucalyptus. On the basis of present findings it may be concluded that Eucalyptus wood of eight years age should be preferred for dissolving pulp manufacture over four or six years of age, because of its low ash contents.

No consistent relationship was found between age of tree and cold water and hot water soluble extractives of the wood. However, the cold water solubles ranged between 2.4 and 5.4 percent in the tree of four to eight years of age respectively. Similarly hot water solubles were 3.8 percent for the tree of four years and 8.4 percent for trees of eight years age. Both cold water and hot water solubles in the trees of 6 years were more than the solubles in the trees of 4 years age. These solubles were more or less similar for the trees of 6 and 8 years. On the other hand alcohol/benzene extractive and 1% alkali solubles increased with the increase in the age of trees. Hollocellulose and alpha-cellulose decreased progressively with the increase in the age of trees. Age of trees had no consistent effect on the percentage of Kurschner cellulose. Lignin content of Eucalyptus increased with the increase in the age of the trees.

Effect of Sampling Position on Chemical Composition

Effect of wood sampling position on its chemical composition is shown in Table 2 and Fig.2 for the samples taken at 1m and 3m height from the butt end of the trees. The hot water alcohol/benzene and alkali solubility and lignin content slightly decreased with the increase in sample height in the trees, while the percentage of ash, hollocellulose and alphacellulose slightly increased with sample height.

Table 2. Effect of sampling position on chemical composition of E. camaldulensis

Position	Ash %	C.W. %	H.W. %	A/B %	1% A.S. %	Lignin %	H-C %	-C %
1m height	0.56	4.81	7.39	2.70	15.10	25.90	74.27	43.71
3m height	0.61	4.17	6.81	2.63	14.46	25.65	74.44	44.25

Ash content is higher in the sample taken at 3m height than in samples at 1m height. From the present finding it is clear that variation among the trees is larger than that within a tree. These findings are quite in accordance with the earlier chemical studies on E. saligna wood by Sardinha and Hughes, (1979).

FIG.1 EFFECT OF AGE ON CHEMICAL COMPOSITION OF E. CAMALDULENSIS WOOD

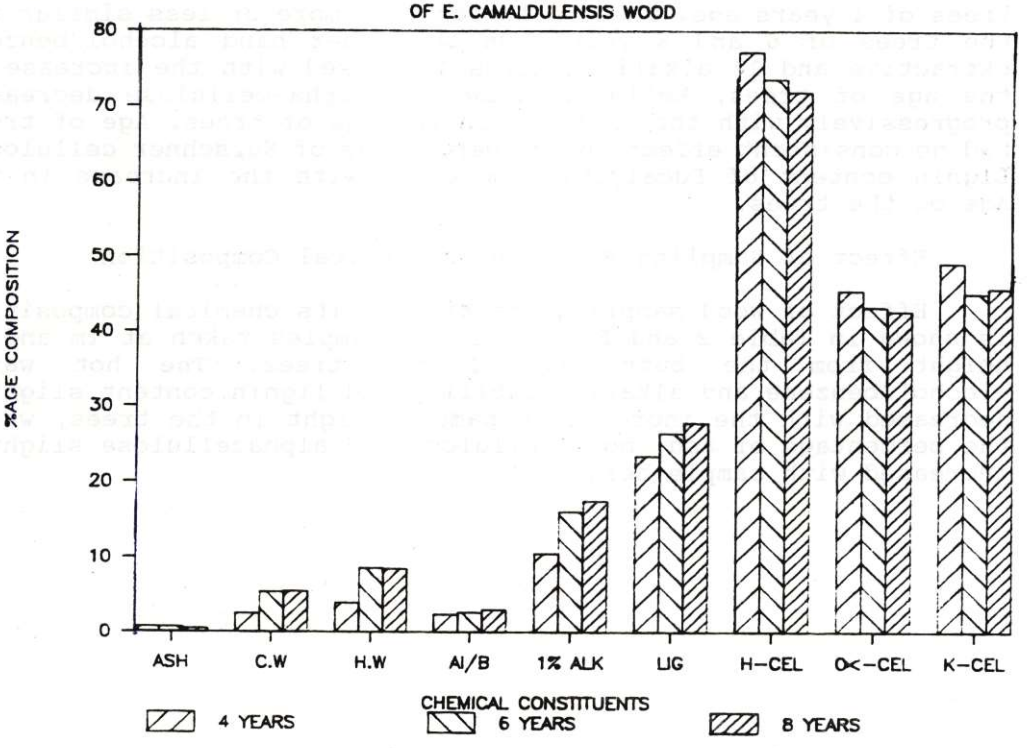


FIG.2 EFFECT OF SAMPLE POSITION ON

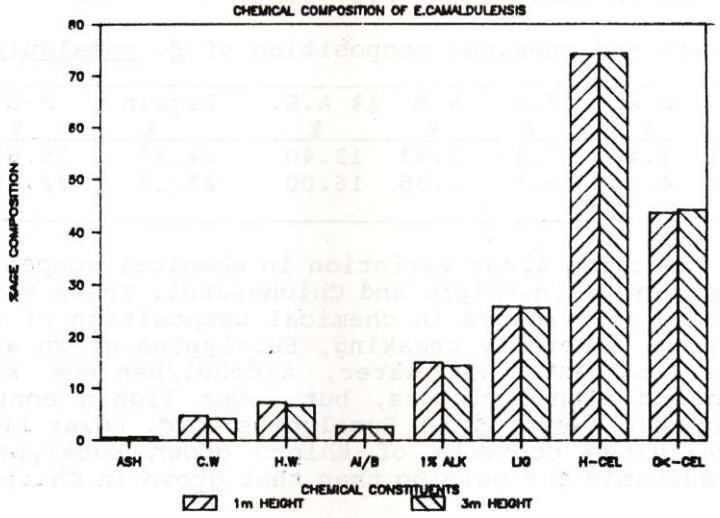
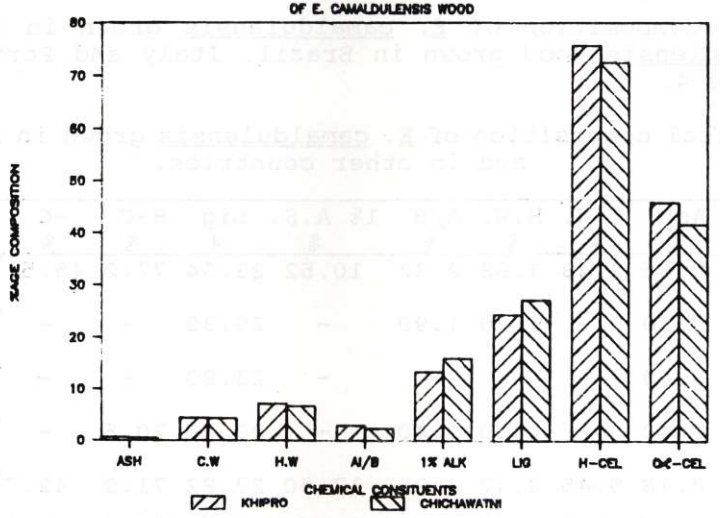


FIG.3 LOCALITY EFFECT ON CHEMICAL COMPOSITION



Effect of Locality on Chemical Composition

The chemical composition of Eucalyptus wood with respect to locality is given in Table 3 and Fig. 3:

Table 3. Locality and chemical composition of E. camaldulensis

Locality	Ash %	C.W. %	H.W. %	A/B %	1% A.S. %	Lignin %	H-C %	-C %
Khipro	0.64	4.46	7.18	2.92	13.40	24.47	75.81	45.98
Chicha-watni	0.51	4.38	6.75	2.35	16.00	27.25	72.69	41.70

Table 3 indicates clear variation in chemical composition of E. camaldulensis grown in Khipro and Chichawatni. These variations may be related to differences in chemical composition of soil and growth conditions. Generally speaking, Eucalyptus grown at Khipro has higher ash content, hot water, alcohol/benzene solubles, hollocellulose and alphacellulose, but lower lignin contents as compared to the chichawatni grown Eucalyptus wood. Lower lignin and higher alphacellulose contents of Khipro grown Eucalyptus wood makes it more suitable for pulping than that grown in Chichawatni.

Comparison of Chemical composition of E. camaldulensis grown in Pakistan with E. camaldulensis grown in other countries.

Chemical composition of E. camaldulensis grown in Pakistan and E. camaldulensis wood grown in Brazil, Italy and Portugal is given in Table 4.

Table 4. Chemical composition of E. camaldulensis grown in Pakistan and in other countries.

Age yrs	Country	Ash %	C.W. %	H.W. %	A/B %	1% A.S. %	Lig %	H-C %	-C %		K-C %
4	Pakistan	0.66	2.48	3.88	2.32	10.52	23.34	77.2	45.5	***	49.15
4	Brazil	0.80	-	1.70	1.90	-	29.30	-	-	**	50.00
8	Italy	0.40	-	-	-	-	23.90	-	-	**	43.60
8	Portugal	0.40	-	4.30	1.40	-	29.10	70.6	-	**	43.00
8	Pakistan	0.46	5.45	8,47	2.98	17.50	27.82	71.9	42.7	***	45.80

*** Kurschner, Popik Cellulose, 1962
** Cross-Bevan Cellulose

Brazil grown E. camaldulensis at the age of 4 years has higher lignin content than E. camaldulensis grown in Pakistan. Amount of extraneous substances are also low in Brazil grown Eucalyptus than the Pakistani grown. However, cellulose contents are comparable for both the localities.

Portugal, Italy and Pakistan grown E. camaldulensis wood has similar ash contents at the age of eight years, whereas lignin content differed markedly from each other. Italian grown Eucalyptus has the lowest lignin and Portugal grown has the highest lignin content of 23.9 and 29.2 percent, respectively at the age of eight years. Pakistan grown Eucalyptus has lignin content of intermediate value. Hot water solubles are quite high in case of Pakistan grown E. camaldulensis wood.

CONCLUSION

It is concluded from the above results that chemical composition of Eucalyptus wood is slightly influenced by the age of tree and locality factors. E. camaldulensis grown in Pakistan is comparable in chemical composition to that grown in various parts of the world and is equally suited for the manufacture of pulp and paper products.

REFERENCES

1. Barrichelo, L.E.G. and Brito, J.O. (1976). Potential of tropical eucalypt species for production of bleached kraft pulp. IPEF, 13: 9-38.

2. Bland, D.E. Menshun, M. (1970). The composition and reactive group of one lignin of Eucalyptus regnans Appita 23, 427-33.

3. Bosia, A. (1963). Paper making properties of six Eucalyptus species. Cellulosa e Carta No. 14: 5, 9-18.

4. ERICKSON, H.D. (1962). Some aspects of method indetermining Cellulose in wood. Tappi 45:710-719.

5. Higgin, H.G. (1978). Pulp and Paper in Eucalyptus wood production (Ed) Hills and Brown, CSIRO, Australia

6. Kawamura, I. and D.E.Bland (1967). The lignin of Eucalyptus wood for tropical and temperature zone Holzforschung 21, 65-74.

7. Kurschner, K. and Popik, M.G. Chemical composition and analysis of wood. Wood Chemistry, Ultrastructure reactions. Walter de-Gruyter Berlin (1984). pp.26-65.
8. Queiroz, M.G. (1971). The behavior of several species of Eucalyptus in Sulphate Pulping ECE/FAO Symposium on the production and Industrial utilization of Eucalyptus. Rome (1971), 49-58.
9. Sardinha, R. and Hughes,J.F. (1979). Anais Insituto Superior de Agronomia (Lisboa) Vol. 38: 105
10. Shigo, A.L. and Hills, W.E. (1972). Heartwood, discolored wood and micro-organism in living trees. Ann. Rev Phytopathol. 11, 197-222.
11. SIDDIQUI,K.M. (1976). Relationship between cell wall morphology and chemical composition of Earlywood and Latewood in two coniferous species. Pak.J. For.26:21-34.
12. Siddiqui, K.M., J.A. Khan, and S.M. Yasin (1984). Eucalyptus camaldulensis DEHN., its growth properties and utilization. Bulletin No. 4. Pakistan Forest Institute, Peshawar.
13. Singh, V., Krishan Lal, S.S. Bhandari, S.P. Singh (1986). Effect of locality of growth and fibre characteristics of Leucaena leucocephala on Kraft pulping. Ind Forester-1986 (12). 1104-1113.
14. Watson, A.J. and W.E. Cohen (1969). Pulping of Eucalyptus; An historical survey. Appita Vol. 2. No. 4.
15. WISE, L.E., M. MURPHY & A.A.D. addieco. (1946). Chlorite holocellulose. Its fractionation and bearing on summative wood analysis and on studies on the hemicelluloses. Paper Trade. J. 122:35-43.