SUITABILITY OF DIFFERENT EUCALYPTUS SPECIES FOR PULP AND PAPER ON THE BASIS OF FIBER MORPHOLOGY

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Abstract

Wood samples of locally grown *Eucalyptus camaldulensis, E. cladocalyx, E. fruticetorum, E. microcorys, E. pallidifolia, E. redunca, E.crebra, E.tereticornis, E. microtheca, E. melanophloia, E. ochrophloia, E. torelliana* and *E. citriodora* were studied for their fibre morphological characteristics. Runkel ratio, felting power, flexibility co-efficient and rigidity co-efficient ratios were derived from the average values of fiber dimensions. *E. camaldulensis, E. crebra, E. tereticornis*, and *E. torelliana* were found more suitable for making paper of better properties as compared to the other species on the basis of Runkel ratio. Due to maximum fibre lumen width and flexibility co-efficient ratio, minimum fibre wall thickness and rigidity co-efficient ratio, *E. crebra* was found the most suitable for high bursting strength, tensile strength, folding endurance, flexible, dense and well formed paper whereas, *E. citriodora* for high tearing resistance and well bonded paper due to maximum fibre length and felting power ratio.

Introduction

Eucalyptus is one of the fast growing species which is native to Australia. Its different species are planted in arid areas of the world. In Pakistan it is successfully growing throughout the plains and hills. It is an evergreen tree, grows up to 40 meters in height and a diameter of 1 to 2 meters. The wood is twisted and interlocked grained, medium coarse and uneven textured, hard, elastic and resilient. Locally it is used for carriages, fuel, charcoal and boards making etc. (Sheikh, 1990).

At present in Pakistan pulp and paper industry is based on non-woody raw materials such as bagasse, rice, wheat straws and grasses etc. which are short in supply because of their seasonal production and also produce low quality paper

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because of low fiber morphological characteristics. On the other hand countries like Australia, Brazil, India and Israel etc. are using wood fibers for pulp production. This study was carried out to assess the suitability of various eucalyptus species on the basis of fibre morphology for the manufacturing of paper having different properties.

Fibre length generally influences the tearing strength of paper. Greater the fibre length, higher will be the tearing resistance of paper (Watson and Dadswell, 1961). On the other hand longer fibers tend to give a more open and less uniform sheet structure (Dadswell and Watson, 1962). Fibre diameter and wall thickness governs the fiber flexibility (Watson, 1967). Fibre lumen width effects the beating of pulp. Larger the fiber lumen width better will be the beating of pulp because of the penetration of liquids into empty spaces of the fibers (Brit Kenneth, 1970). Thick walled fibers adversely effect the bursting strength, tensile strength and folding endurance of paper. Paper manufactured from thick walled fibers will be bulky, coarse surfaced and contain a large amount of void volume. On the other hand paper prepared from thin walled fibers will be dense and well formed (Dadswell and Watson, 1962).

Calculated wood properties also help to assess different properties of paper. Favorable pulp strength properties are usually obtained when value of Runkel ratio is 1 (Dadswell and Watson, 1962). High Runkel ratio fibers are stiffer, less flexible and form bulkier paper of lower bonded areas than low Runkel ratio fibers (James, 1980). Strength properties of paper such as tensile strength, bursting strength and folding endurance are affected mainly by the way in which individual fibers are bonded together in paper sheet. The degree of fibre bonding depends largely on the flexibility and compressibility of individual fibers (Watson, 1967). Higher the value of fibre length/width ratio, greater will be the fibre flexibility and better the chance of forming well bonded paper (James, 1980). An increase in rigidity of fibers results in decrease in fibre bonding (Dinwoodie, 1966).

Materials and Methods

Wood samples of *Eucalyptus camaldulensis, E. cladocalyx, E.fruticetorum, E. microcorys, E. pallidifolia, E. redunca, E. crebra, E. tereticornis, E.microtheca, E. melanophloia, E. ochrophloia, E. torelliana* and *E. citriodora* were collected from Pakistan Forest Institute Research garden.

A small portion of wood from each species was macerated in the mixture of nitric acid (20%) and Potassium chlorate to separate the fibers. Cross section of wood from each species was also prepared by standard laboratory procedure (Anon, 1971) and studied under the microscope to observe the fibre diameter and wall thickness. Data was collected for fibre length, diameter, lumen width and wall thickness in each species and analyzed for average values, standard deviation and co-efficient of variation.

Calculated wood properties such as Runkel ratio, Felting power, Flexibility co-efficient and Rigidity co-efficient ratios were also derived from the average values of fibre dimensions for each species.

Results and Discussion

Fibre dimensions

Average values given in the table indicate that maximum fibers length was found in *E. citriodora* followed by *E. redunca, E. ochrophloia, E.microcorys, E. microtheca, E. torelliana, E. camaldulensis, E. tereticornis, E.pallidifolia, E. melanophloia, E. crebra, E. cladocalyx* and *E. fruticetorum.*

The largest fibre diameter was observed in *E. torelliana* followed by *E.crebra, E. microtheca, E. camaldulensis, E.tereticornis, E. melanophloia, E.citriodora, E. ochrophloia, E.microcorys, E. pallidifolia, E. redunca, E.cladocalyx* and *E.fruticetorum.*

Fiber with widest lumen width were observed in *E. crebra* followed by *E.torelliana, E. camaldulensis, E. tereticornis, E.microtheca, E. citriodora, E.melanophloia, E. microcorys, E.redunca, E. ochrophloia, E.fruticetorum, E.cladocalyx* and *E.pallidifolia.*

Minimum fibre wall thickness was found in *E. crebra* whereas, maximum in *E. ochrophloia.* The other species stood in between.

Calculated wood properties

Runkel ratio (2 x wall thickness/lumen width) indicates the relation between the fibre lumen width and wall thickness. Value of this ratio below 1 (standard value) was calculated in *E. camaldulensis, E. crebra, E. tereticornis*, and *E. torelliana*. Whereas, in *E. citriodora, E. cladocalyx, E. fruticetorum, E.microcorys, E. pallidifolia, E. redunca, E. microtheca, E. melanophloia* and *E. ochrophloia*, value of this ratio was higher (fig. 1).

Felting power is the ratio of fibre length to diameter. Highest value of this ratio was calculated in *E. citriodora* followed by *E. redunca, E. caldocalyx, E.microcorys, E. pallidifolia, E. fruticetorum, E. ochrophloia, E. microtheca, E.melanophloia, E. camaldulensis, E. tereticornis, E. torelliana* and *E. crebra* (fig.2).

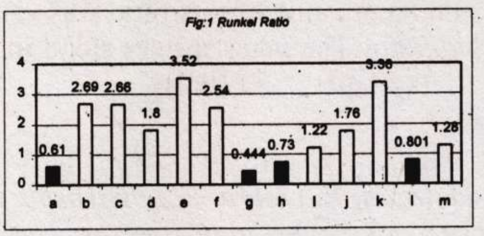
Table 1. Fibre dimensions in different Eucalyptus species

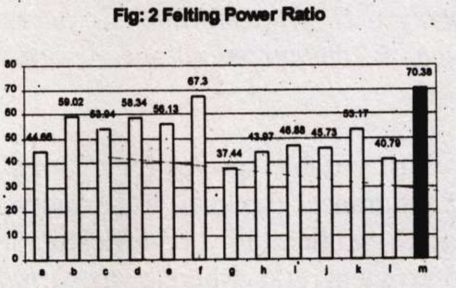
(average values)

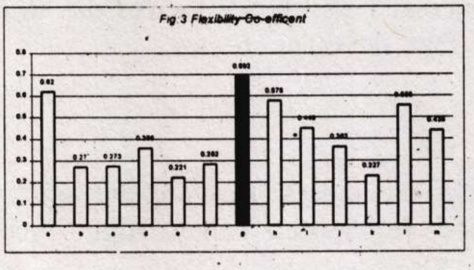
Species	Fibre length (mm)	S.D	C.V %	Fibre diameter (µ)	S.D	C.V %	Fibre wall thickness (µ)	S.D	C.V %	Fibre lumen width (µ)
E.camaldulensis	0.766	0.18	24.2	17.15	3.44	20.0	3.25	0.54	16.6	10.65
E.cladocalyx	0.679	0.09	14.0	11.49	1.00	8.7	4.19	0.51	12.2	3.11
E.fruticetorum	0.616	0.06	10.7	11.42	1.65	14.5	4.15	0.37	9.11	3.12
E.microcorys	0.811	0.12	15.7	13.90	2.14	15.3	4.47	0.69	15.5	4.96
E.pallidifolia	0.741	0.08	11.1	13.20	1.69	12.8	5.14	0.73	14.2	2.92
E.redunca	0.844	0.12	14.9	12.54	1.7	14.1	4.50	0.56	12.5	3.54
E.crebra	0.711	0.13	18.6	18.99	2.91	15.3	2.92	0.47	16.2	13.15
E.tereticornis	0.744	0.16	22.3	16.92	2.54	15.0	3.57	0.63	17.8	9.78
E.microtheca	0.806	0.07	9.6	17.19	2.69	15.6	4.74	0.90	19.0	7.71
E.melanophloia	0.730	0.09	12.8	15.96	2.87	17.9	5.09	1.35	26.6	5.78
E.ochrophloia	0.821	0.12	15.5	15.44	1.62	10.5	5.96	0.97	16.3	3.52
E.torelliana	0.798	0.14	18.7	19.56	1.84	9.4	4.35	0.98	22.6	10.86
E.citriodora	1.11	0.21	18.8	15.77	3.02	19.1	4.43	1.03	23.3	6.91

Flexibility co-efficient is the ratio of fiber lumen width to fiber diameter. Maximum value of this ratio was calculated in *E. crebra*, followed by *E.camaldulensis, E. tereticornis, E. torelliana, E. microtheca, E. citriodora, E.melanophloia, E. microcorys, E. redunca, E. fruticetorum, E. cladocalyx, E.ochrophloia* and *E. pallidifolia* (fig.3).

Calculated Wood Properties in Different Eucalyptus Species







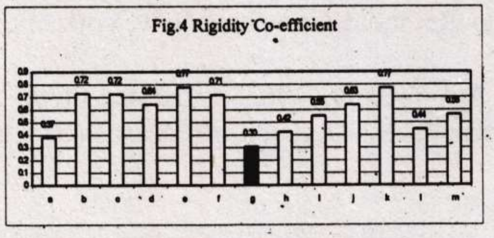


Fig. 1-4. a = *E.camaldulensis*, b = *E.cladocalys*, c = *E.fruticetorum*, d = *E.microcorys*, e = *E.pallidifolia*, f = *E.redunca*, g = *E.crebra*, h = *E.tereticornis*; i = *E.microtheca*, j = *E.melanophloia*, k = *E.ochrophloia*, l = *E.torelliana*, m = *E..citriodora*

Rigidity co-efficient is the ratio of fiber cell wall thickness to fiber diameter. In this study minimum value of this ratio was calculated in *E. crebra* and maximum in *E. pallidifolia*. The other species stood in between (fig.4).

Conclusions

Eucalyptus camaldulensis, E. crebra, E. tereticornis and E. torelliana can be used for making paper of better properties as compared to that from *E.citriodora, E. cladocalyx, E. fruticetorum, E. microcorys, E. pallidifolia, E.redunca, E. microtheca, E. melanophloia* and *E. ochrophloia* on the basis of Runkel ratio.

E. crebra is the most suitable species for making high bursting strength, tensile strength, folding endurance, flexible, dense and well formed paper due to maximum fibre lumen width and flexibility co-efficient ratio, minimum fibre wall thickness and rigidity co-efficient ratio, whereas, *E. citriodora* is the most suitable for high tearing resistance and well bonded paper due to maximum fiber length and felting power ratio than the other species.

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