THE WOOD AND PULPING PROPERTIES OF CHIR PINE (*PINUS ROXBURGHII SARG*).

PART I. WOOD PROPERTIES

K. M. SIDDIQUI*

Abstract

This study describes in three parts the results of investigations on wood and pulping properties of chir pine from natural forests in Hazara region of Pakistan at laboratory and pilot scale. Tests were conducted to examine the effect of tree age and the presence of resin in chir pine wood on its pulping characteristics. Physical, anatomical and chemical properties of wood samples from 15 trees of three age groups were determined in the standard manner. Considerable variation was observed within individual trees as well as between trees of different age groups in moisture content, bark percent, latewood percent, wood specific gravity, fibre length and diameter, extractives contents. Trees of 36–45 year age were found to have most suitable wood quality for pulping purpose as compared to those of lower and higher age groups.

Introduction

Chir pine (*Pinus roxburghii* Sarg.) has a very large natural range of distribution in sub-tropical regions of India and Pakistan and is found from 500 to 2000 metres elevation (1). In Pakistan, it grows naturally in Azad Kashmir, Murree, Hazara and Swat Regions. It is a gregarious species, forming pure forests of considerable extent. It is also a fairly fast growing coniferous species. The trees are tall and evergreen with a clear, straight and cylindrical bole, whorled branches, and narrow crown. Its bark is reddish brown and rough and cut by deep fissures into irregular plates. The sapwood is white to creamy white in colour and heartwood is light and red when first exposed, turning reddish brown with age. The wood is resinous and trees are tapped for resin. Chir pine is a popular timber in Pakistan, and is generally used for roofing, cheep joinery, packing cases and constructional work (2).

A number of activities are proposed under a multi-phased project of the World Bank entitled "Hazara Forestry Pre-investment Project" for the chir pine forests of Hazara. These include, among others, pulping tests to determine suitability of chir pine wood as raw material for pulp manufacture. The tests were carried out at laboratory-and mill-scale in the Forest Products Research Division of the Pakistan Forest Institute, Peshawar and Adamjee Paper and Board Mills, Nowshera. The results are described in three parts. This article describes wood properties of chir pine.

Material and Methods

Sampling procedure:–Fifteen dominant and co-dominant trees of chir pine ranging in age from 26 to 54 years, were selected in compartment 3(i) and (ii) in Batrasi Reserved Forest

* The author is Director, Forest Products Research Division, Pakistan Forest Institute, Peshawar.

of Siran Forest Division in Hazara in March, 1980 and felled at ground level. Following felling, total height, mid height, and diameter at breast height were recorded for all trees. Total volume, over bark and under bark, was also determined for these trees. Some data are given in Appendix I. The trees were grouped on the basis of their age e.g. tree Nos. 1 to 4 as G–1 (26–35 years), tree Nos. 5–9 as G–2 (36–45 years) and tree Nos. 10 to 15 as G–3 (46–54 years). One meter long billets from two positions with mid-point at breast height and mid-height and half meter long billet from top end (50 mm d.o.b.) were cut and marked for tree number and their position in the tree. In all, 3 sample billets from each tree and 45 sample billets from 15 trees were obtained. One disc, 2.5 cm thick, was sawn from each billet taken from above-mentioned three positions in the tree for wood and pulp studies in the laboratory.

Determination of physical properties:–The moisture content of the discs was determined by weighing them before and immediately after drying at 105°C and was computed as percentage of moist wood weight. The bark ratios were computed as the percentage of bark by overbark volume of the tree (upto 50 mm d.o.b.) and by oven-dry weight of discs alongwith bark. Percent latewood was directly measured on the sample discs in fully saturated condition with the help of Olympus travelling microscope fitted with a micrometer. Application of 0.1 gm. methylene blue and 0.1 gm. malachite green in 166 ml. of 10 percent ethyl aloohol provided a contrast and facilitated the measurements. Wedge-shaped block were removed from each disc representing wood from pith to bark for measurement of specific gravity. Three blocks were cut at an equal distance from each wedge, making 9 sample blocks for each tree. Wood specific gravity was determined by the maximum moisture content method. (3).

Determination of anatomical properties:–Fibre length determinations were made on radial strips of compression-free wood from the discs. These were cut to match-stick-size splinters and boiled in a mixture of 20% nitic acid and potassium chlorate until the fibres started separating from each other. After thorough washing with water, fibres were stained with safranin and mounted on slides. Fibre length was measured by projection method. About 500 measurements were made on each disc thus totalling more than 1500 for each tree. Tangential cell wall thickness was measured by the method of Richardson (4). The radical lumen diameter of five tracheids was also measured separately.

Chemical analyses:–The chemical analysis of wood was carried out on a composite sample. A small quantity of chips was taken at random from chip lots prepared from each group of trees for pulping trials and ground in a Willey mill. The fraction of ground wood which passed through a B.S. 40 mesh sieve and retained on B.S. 60 mesh sieve was used for chimical analysis. The following methods were used for determination of different chemical constituents in the wood samples.

Sampling and preparing wood for analysis	TAPPI Standard Method T–11 m–59
Al cohol-Benzene solubility	TAPPI Standard Method T–6 OS–59
Hot water solubility	TAPPI Standard Method T–1 OS–59.

Lignin content	TAPPI Standard Method T–13 OS–54.
Hollocellulose	TAPPI Standard Method T–13 OS–54.
Hollocellulose	Siddiqui (5)
Alphacellulose	Siddiqui (5)

Results and Discussion

Moisture content:–The moisture content of discs from 15 trees, about two weeks after the trees were felled, was 50 to 60 percent. Approximately 2.5 ton of freshly-felled wood would be needed to supply one ton of oven-dry wood.

Bark ratio:–The bark ratios for the individual trees are given in Appendix I and the mean values alongwith range for the three groups of trees are given in Table 1. As expected, percent bark by volume is higher in young trees (G–1) than in old trees (G–2 and G–3). However, average bark content in chir pine trees appears to be much higher than that in temperate coniferous pulpwood species as well as pines of southern U.S.A. (6).

Table 1.–*Bark ratios for chir pine trees of different age groups.*

Age group	By volume		By weight	
	Mean %	Range %	Mean %	Range %
G–1	34.8	24.1–41.0	20.8	18.7–21.6
G–2	27.5	22.5–34.0	13.3	11.2–15.4
G–3	24.2	19.9–30.2	10.6	8.1–12.8

Percent latewood:–The percent latewood for each tree was calculated from the sum of latewood bands in all growth rings over the cross-section of the discs. The mean values of percent latewood at different heights in the trees of three age groups are given in Table 2. Mean value of percent latewood is higher in medium age trees (G–2) than that in younger and older trees (G–1 and G–3). It is maximum at breast height level (D–1) and decreases with stem height (D–2 and D–3). The proportion of latewood in any wood sample depends upon (i) species, (ii) age (iii) growth rate and (iv) horizontal and vertical position in the tree (7). The observed differences in latewood content between groups of trees is due to the differences in their age.

Table 2. –*Percent latewood at different heights in the trees of three age goups.*

Age group	Percent latewood			Mean
	D–1	D–2	D–3	
G–1	29	29	21	26.3
G–2	42	36	26	34.7
G–3	39	36	21	32.0

D–1, disc out at d.b.h. : D–2, disc out at mid-height and D–3, disc out at top (50 mm d.o.b.)

Specific gravity:–Wood specific gravity directly affects pulp yield (5). Wood of high specific gravity gives high pulp yield. Appendix I gives the specific gravity values for individual trees. The mean value is a weighted mean for each tree and the range gives the maximum and minimum values for the three discs out at different heights in each tree. These are at about middle of the range of densities of softwoods normally used in the pulp industry (Rydholm (8) gives the range as 0.31 to 0.56.) As shown in Table 3, the specific gravity is maximum in G–2 trees and minimum in G–1 trees. It is also maximum in lower part (D–1) and minimum in the top part (D–3) of the tree. It increases from pith to the bark in all trees. (Table 4). Further, although percent latewood is not considered to be a reliable indicator of wood specific gravity (7), still, in the present investigation, the variation in specific gravity tends to be directly related to the differences in the proportion of latewood in the wood samples.

Table 3:– *Variation in specific gravity at different heights in the trees of three age groups.*

Age group	Specific gravity			
	D–1	D–2	D–3	Mean
G–1	0.449	0.443	0.400	0.431
G–2	0.510	0.485	0.454	0.483
G–3	0.483	0.466	0.466	0.459

Table 4:– *Variation in specific gravity across cross-sections of trees.*

Age group	Specific gravity		
	Near pith	Middle	Near bark
G–1	0.410	0.445	0.470
G–2	0.447	0.512	0.551
G–3	0.425	0.467	0.493

Fibre length:– All fibre dimension parameters are important in determining pulping quality of wood samples (8). Detailed analyses were carried out to determine fibre length distribution at different height levels in trees of various age groups. The results are given in Appendix II. Other parameters are given in Appendix I. Mean values of fibre length for trees of each group and its variation at different height levels within these trees are presented in Table 5.

Table 5:– *Fibre length data of chir pine*

Age group	Fibre length, mm			
	D–1	D–2	D–3	Mean
G–1	3.72	3.60	3.30	3.53
G–2	4.26	4.36	3.73	4.11
G–3	3.97	4.20	3.04	3.73

Fibre length is maximum in 36–46 years old trees (G–2 group) and minimum in 26–35 years old trees (G–1 group). It generally increases from D–1 to D–2 position and decreases from D–2 to D–3 position, except in G–1 where a slight decrease from D–1 to D–2 position is noticed. Similar results have been reported for chir pine by Ahmad (9). As far as fibre length distribution is concerned, it is seen from data in the Appendix that the range of fibre length is almost identical in all three groups of trees and majority of fibres in them fall within the range of 2.5 to 5.5 mm. It also appears from data that chir pine trees have high proportion of long fibres at the age of 40–45 years, e.g., 83.7% of 3.5 to 5.5 mm long fibres as compared to 66.7 % and 67.6% fibres of similar length in G–1 and G–3 trees respectively.

Fibre diameter and cell wall thickness:– The values of fibre and lumen diameter, and cell wall thickness are shown in Table 6. The increase in cell wall thickness is found to be closely related with percent latewood and wood specific gravity in three groups of trees. Cell wall thickness and Runkel's ratio are low in G–1 as compared to G–2 and G–3 trees which suggest that a well-bonded sheet could be made when wood from G–1 trees if converted into pulp.

Table 6:– *Fibre diameter, lumen diameter and cell wall thickness in chir pine trees.*

Age group	Fibre diameter microns	Lumen diameter microns	Cell wall thickness microns	Runkel's ratio
G–1	39.1	27.0	3.3	0.245
G–2	41.7	28.0	3.7	0.265
G–3	41.1	27.7	3.7	0.260

Chemical composition:– The extractives values were computed as a percentage of oven-dry wood weight and values of other chemical constituents are based on oven-dry exrracted wood weight. The total extractives are almost the same in three groups of trees (Table 7). However, alcohol-benzene soluble extractives are higher and water soluble extractives lower in young trees as compared to those in old trees of chir pine. The extractives content has a direct effect on pulp yield; a higher content reduces pulp yield. On the other hand, maximum holocellulose and alpha cellulose contents are observed in G–2 trees. It can also be seen from the above results that G–2 and G–3 trees have almost similar content of chemical constituents which suggests that these two groups would produce pulp of comparable yield under identical pulping conditions.

Table 7:– *Chemical Composition of Chir pine*

Age group	Alcohol + benzene extractives %	Hot water extractives %	Holo cellulose %	Alpha cellulose %	Lignin %	Ash %
G–1	4.0	2.7	71.8	49.3	28.7	0.35
G–2	3.7	2.8	74.0	52.5	27.2	0.41
G–3	2.9	4.0	73.1	51.8	27.1	0.38

CONCLUSION

The results of this investigation on wood properties of chir pine indicate its suitability for pulp and paper manufacture. The wood properties of chir pine compare favourably with those of softwood species commonly used for this purpose. The bark content is however, much higher in chir pine than temperate coniferous species as well as pines of Southern U.S.A. Its wood specific gravity is about the middle of the range of densities of softwoods normally used in the pulp industry. The fibre length of chir pine is quite large. On the other hand, the extractives content of the wood was found to be fairly low. Therefore no special problems of deresination and pitch troubles should be expected during pulping of chir pine wood.

Comparison of wood properties of chir pine trees belonging to three age of groups showed that 36 45 years old trees have higher percent latewood, wood specific gravity and fibre length than younger and older trees. This will have a direct effect on pulp yield and strength properties of paper made from it.

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APPENDIX I

Trees measurements and physical properties of chir pine wood

Tree No.	Tree age, years	Tree height m	D.B.H. O.B., cm	Moisture content %	Bark, % by volume	Bark, % by weight	Latewood %	Specific gravity Mean	Specific gravity Range	Fibre diameter microns	Lumen diameter microns	Cell wall thickness microns
1.	26	12.2	15,7	48	37.4	18.7	23.8	0.398	0.365–0.423	41.9	30.2	3.2
2.	27	11.3	17.0	54	41.0	21.5	23.9	0.422	0.373–0.468	37.7	26.3	3.1
3.	30	13.7	18.0	47	24.1	21.6	28.7	0.475	0.459–0.496	40.1	26.5	3.8
4.	35	15.5	20.1	52	36.6	21.2	28.8	0.428	0.404–0.453	36.9	25.2	3.3
5.	40	16.8	21.8	56	34.0	15.4	31.7	0.533	0.462–0.527	40.3	26.7	3.8
6.	41	19.2	22.1	52	23.1	11.2	35.6	0.513	0.488–0.559	40.9	28.5	3.3
7.	44	19.8	29.2	49	26.1	14.1	38.4	0.446	0.407–0.502	43.9	28.9	4.1
8.	45	21.0	30.5	51	31.8	13.3	33.6	0.491	0.456–0.515	40.9	27.0	3.8
9.	45	18.6	25.1	58	22.4	12.3	34.0	0.462	0.455–0.469	42.5	29.0	3.6
10.	48	21.9	30.5	69	30.2	12.8	35.3	0.466	0.357–0.527	41.8	28.6	3.1
11.	48	22.9	27.9	50	21.7	12.8	33.9	0.479	0.444–0.515	39.4	25.4	3.8
12.	49	21.3	29.2	60	21.8	8.1	24.2	0.444	0.405–0.469	42.0	30.1	3.0
13.	49	21.0	30.5	54	26.0	8.5	32.9	0.484	0.462–0.496	40.7	26.4	4.4
14.	52	21.4	33.5	53	25.5	10.2	30.1	0.387	0.369–0.407	41.2	27.8	3.5
15.	54	21.0	27.9	55	19.9	11.1	30.9	0.495	0.479–0.510	41.3	27.7	3.8

APPENDIX II

Fibre length distribution at different height levels in Chir pine trees of three age groups

Disc No.	Fibre length interval mm	G–1		G–2		G–3	
		No. of fibres	% of all fibres	No. of fibres	% of all fibres	No. of fibres	% of all fibres
D–1, disc cut at breast height level	0–1	–	–	–	–	3	–
	1–2	88	4.4	1	–	124	4.1
	2–3	368	18.5	179	7.3	454	15.2
	3–4	746	37.5	881	35.4	940	31.4
	4–5	593	39.8	868	34.9	932	31.0
	5–6	172	8.6	486	19.5	476	15.8
	6–7	16	0.8	72	2.9	74	2.5
	7–8	7	0.4	3	–	2	–
D–2, disc cut at mid height	0–1	–	–	–	–	–	–
	1–2	113	5.7	4	0.2	52	1.7
	2–3	458	22.8	172	7.0	392	13.1
	3–4	748	37.2	746	30.2	883	29.6
	4–5	500	24.9	915	37.0	935	31.3
	5–6	179	8.9	526	21.3	540	18.1
	6–7	10	0.5	99	4.0	160	5.3
	7–8	1	–	8	0.3	24	0.8
D–3 disc cut near the top	0–1	–	–	6	0.2	20	0.7
	1–2	231	9.3	183	7.4	496	16.6
	2–3	861	34.6	451	18.2	986	33.0
	3–4	694	27.9	796	32.1	930	31.1
	4–5	521	20.9	723	29.2	449	15.0
	5–6	173	6.9	280	11.3	106	3.5
	6–7	11	0.4	34	1.4	3	0.1
	7–8	–	–	6	0.2	–	–