Summary of F.R.I. Investigations on Effects of Storage on Paper Making Raw Materials

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The main raw materials used by the paper industry are bamboo, wood, and grass and other. With the increase in production, the amount of bamboo and wood used by the industry is bound to increase. The magnitude of the raw materials required in 1980 and 1990, as estimated by National Commission on Agriculture is 50,00,000 cu.m. of wood and 22,00,000 tonnes of bamboo and 1,27,00,000 cu.m. of wood and 20,00,000 tonnes of bamboo respectively. The procurement of such amounts of forest produce will be dependent on the forest management policies as well as on weather conditions. Normally 6 to 9 months requirement will have to be stored for smooth running of the mill and hence storage of these materials is a basic problem facing the industry.

The results of the extensive work carried out at the Forest Research Institute on effects of storage of bamboo and of wood and the effects of various microorganisms on bamboo and on wood and on the resultant chemical and mechanical pulps are summarised.

Introduction

To meet the ever increasing demand of paper more and more fibrous raw materials like bamboo, wood, grass etc. will have to be made available at economic price on sustained yield basis.

National Commission on Agriculture has projected the future raw material requirements of pulp and paper industry as recorded in Table I.

TABLE I

Projections by National Commission of Agriculture on Raw Material Requirements by Pulp & Paper Industry

Sl. No.	*Product*	*Requirement of the product in '000 tonnes*		*Requirement of wood in '000 m and '000 tonnes for bamboo*	
		1980	*1990*	*1980*	*1990*
1.	Hardwood mechanical pulp	219.0	500.4	504.0	1150.0
2.	Mechanical pulp from conifers	117.0	300.2	269.0	690.5
3.	Chemical wood pulp dissolving	315.0	647.0	1417.0	2912.0
4.	Chemical pulp bamboo	733.0	651.0	2199.0	1953.0
5.	Chemical wood pulp (hardwood)	121.0	382.0	484.0	1529.0
6.	Chemical wood pulp (conifers)	257.0	754.0	1285.0	3770.0
7.	Hardwood semi-chemical pulp	537.0	1071.0	1074.0	2679.0
8.	Chemical pulp (Bagasse etc.)	30.0	26.5	57.0	48.0

From the projection given in Table I, it is clear that the magnitude of raw material requirements of the industry is of a high order. The procurement of the material will be dependent on the forest management policies as well as on the weather conditions prevailing in the area of extraction. In normal practice it is essential to have the raw material stored either at the mill or in the forest for 6 to 9 months. In India, the usual practice is to store wood in the log form after debarking, bamboo in lengths of 2½ metres and bagasse in a baled form.

In the Timber Trend Study for India (1958) combined losses in forest wealth due to causes like fire, decay, insects and windfall were estimated at 14%. When the forest is felled, natural resistance present in the living trees is lost and the timber is liable to degradation due to attack by fungi, insects, etc. As stated earlier these materials have to be stored and serious losses may occur if the storage period is prolonged or the material is not properly stored. The losses on storage are not accurately known and may not be properly appreciated and in some cases under estimated. The presence of fungi decay in wood effects the appearance, physical properties, chemical composition, and microscopic structure of the wood. Decay in wood is usually accompanied by a change in colour; the wood may become either bleached or darkened. Decayed wood is softer and less strong than sound wood. In an advanced stage of decay it may be extremely light in weight, but retains original outward form and structure.

Decomposition of wood by fungi is of two main types, which have been described as "brown rot" and "white rot". In brown rot, the cellulose and other associated carbohydrates are attacked preferentially; the lignin remains in a relatively unchanged condition and the decaying residue gradually turns brown in colour. In white rot, all components of the wood, including the lignin, are decomposed; some times in the residue, patches of a white substance may be observed.

Summary of the work carried out at Forest Research Institute on the effect of Storage on pulping quality of Eucalyptus as well as of bamboo.

Effect of Storage on Pulping of Eucalyptus

Eucalyptus hybird was stored in the Haldwani Division in the open, after debarking. Samples were drawn fresh and after 6 months, 9 months and 1 year of storage. Hot water solubility and 1% Sodium hydroxide solubility were determined. The digestion of the material was carried out using the Sulphate process keeping the chemicals as 18%, sulphidity 25%, bath ratio 1:4 and cooking period 4 hours. The results of the strength properties after beating the pulp to 250 m. are recorded in Table II.[1]

It is seen from the above table that on storage the hot water solubility as well as 1% sodium hydroxide solubility increases. The yield and the properties of the pulp decrease on storage.

Fresh and the stored Eucalyptus hybrid were pulped by the ground wood process. The grinding condition, pulp qualities and strength properties of the pulp blended with 30% bleached beaten Etta reeds chemical pulp are given in Table III.[2]

The power consumption is more and the rate of grinding is less in the case of stored wood than the fresh wood. The brightness and strength properties from stored wood are lower than the fresh wood.

Fresh and Eucalyptus hybrid were pulped by the cold soda pulping process by soaking the chips in 6% caustic soda solution on the o.d. weight of the chips for 3 hours and refined in Sprout Waldron Refiner. This pulp was further bleached with calcium hypochlorite and evaluated after beating to 250 ml. (C.S.F.) and blending with 30% bleached beaten Etta reed chemical pulp. The results are given in Table IV.[2]

The power consumption is lower, the pulp is long fibred and brighter when fresh wood yielded slightly better quality of the pulp.

TABLE II

Sl. No.	*Time of storage*	*Hot water solubility*	*1% sodium hydroxide solubility*	*Yield*	*Breaking length*	*Burst factor*	*Tear factor*
	months	%	%	%	*meters*	—	—
1	2	3	4	5	6	7	8
1.	Fresh	4.6	12.5	49.8	8010	48.3	84.2
2.	6 months	5.5	14.5	48.7	7830	46.6	78.7
3.	9 months	5.7	17.8	44.8	6120	44.2	76.3
4.	12 months	6.0	19.6	40.5	6190	39.1	70.6

TABLE III

Grinding conditions, pulp qualities and strength properties of blended sheets

	Fresh	*Stored*
Pressure during grinding, kg/cm^2	1.1	1.1
Grinding rate, o.d. wood/day, kg	890	875
Power consumption, KWH/tonne o.d. wood	800	820
Freeness of the pulp, ml (C.S.F.)	60	75
Fineness of pulp:		
(i) Retained on 41 mesh, %	0.0	7.5
(ii) Passing through 150 mesh, %	89.0	86.3
Brightness of pulp sheet, MgO=100 (Elrepho)	34	32
Breaking length, metres	1400	1200
Burst factor	5.8	5.6
Tear factor	39.8	30.2
Bulk	3.0	2.8
Brightness of blended sheets, MgO=100 (Elrepho)	44	40

TABLE IV

Refining conditions, pulp qualities and strength properties of the blended sheets

	Fresh	*Stored*
Screened yield, %	77.3	80.6
Power consumption, KWH/tonne o.d. wood	670	810
Freeness of the pulp, ml (C.S.F.)	580	420
Fineness of pulp:		
(i) Retained on 48 mesh, %	47.3	38.3
(ii) Passing through 150 mesh, %	40.8	50.9
Brightness of the pulp sheet, MgO=100 (Elrepho)	28	22
Breaking length, metres	1280	1260
Burst factor	4.4	4.2
Tear factor	26.4	23.4
Bulk	3.1	3.1
Brightness of the blended sheet, MgO=100 (Elrepho)	48	42

Effect of attack by Termities pinil fungus on pulping quality of kail (Pinus wallichiana)

Chipped and screened material from healthy kail and attacked kail were pulped by the sulphate processes using 24 per cent chemicals and bath ratio 1:4 for 4½ hours. The yield and properties of both bleached and unbleached pulps after beating to 300 m. (C.S.F.) are recorded in Table V.[3]

From the results recorded above it is clear that the yield and the strength properties of the pulp from healthy wood are superior to those from the attacked wood.

Effect of Fungus attack on pulping quality of bamboo

These investigations can broadly be classified as under:

(i) Bamboo unflowered.
(ii) Flowered Bamboo.
(iii) Decay in unflowered Bamboo and its effect on pulp.

Many species of decay fungi are known to attack bamboo during storage. Among the important fungi are *Deadalea flavida, Trpex flevnus, Polyperus sancuineus* and *Schizephyllum commune.* These fungi cause white rot though other fungi are known to cause brown rot in bamboo. Such decay can take place in the healthy bamboo after it is harvested and stored in the yard. The effect of some of these fungi on pulping quality of *Dendrocalamus strictus* has been studied and the results of the investigations are recorded in the Table VI.[4]

A persual of this Table shows that the lignin content of bamboo chips subjected to fungus attack does not vary appreciably from that of healthy bamboo. No appreciable difference was observed in the yields of unbleached and bleached pulps though chips subjected to fungus attack decreased in weight. The bleach consumption of the pulps from healthy and fungus decayed bamboo was not appreciably different, but the bleached pulp from the latter had a yellower tone.

TABLE V

	Unb'eached healthy wood	*Bleached healthy wood*	*Unbleached attacked wood*	*Bleached attacked wood*
Pulp yield, %	43.1	39.4	33.1	30.6
Breaking length, metres	6270	5680	3300	2910
Stretch, percent	2.5	2.3	2.5	1.3
Tear factor	81.0	75.9	30.0	25.3
Burst factor	43.0	38.1	14.6	14.2
Double folds	870	90	2	2

TABLE VI

Table—Effect of fungus attack on bamboo

Test Material	*Incubation period* months	*Lignin content* %	*Unbleached pulp yield** %	*Bleach consumption* %	*Bleached pulp yield** %	*Strength standard breaking length metre*	*Properties of pulp sheets Burst factor*	*Tear factor*
Healthy bamboo	—	27.55	40.7	8.3	36.2	9140	59.8	148.0
Bamboo infected with *B. sanquineus*	2	26.85	40.4	7.6	36.0	8980	56.4	145.0
	3	28.76	40.2	8.1	35.9	8970	55.3	134.0
	4	26.32	40.5	6.9	36.0	8180	57.8	94.7
	5	26.84	40.4	6.8	36.0	8970	56.9	93.8
Bamboo infected with *D. flavida*	1	28.17	39.1	9.0	35.0	7730	52.5	87.2
	2	27.72	36.6	10.1	32.1	6960	40.9	73.3
	3	26.36	33.7	8.1	29.3	5750	30.4	56.2
Bamboo infected with *L. praerigidue*	3	27.18	40.6	8.0	34.6	6810	43.7	83.3

* Values expressed on the basis of even-dry raw material.

* Bleach consumption expressed as percentage bleaching powder containing 35% available chlorine on the weight of even-dry raw material.

The strength properties of the standard pulp sheets made from the pulps from decayed bamboo chips were appreciably lower than those of pulps from the healthy bamboo. This was more in the case of *Dandales flavida*.

Mature culms of Bamboos tulda from Assam, which had been stored for a year were graded as healthy bamboo, stained bamboo and decayed bamboo. These three varieties were pulped and strength properties were determined. The results indicated that the yield of unbleached pulp from healthy and stained bamboos was similar. However, the yield of unbleached pulp from decayed bamboo was much lower. The strength properties of the pulps from decayed bamboo are appreciably lower than those of sheets made from stained bamboo pulps and the latter were lower than those of sheets made from healthy bamboo. The results are given in Table VII.[5]

TABLE VII

Table—Effects of famous damage to bamboo on pulp yield and sheet strength

Test material	*Unbleached pulp yield %*	*Strength properties of standard pulp sheets*		
		Breaking length metre	*Burst actor*	*Tear factor*
Healthy bamboo	46.0	6600	56.0	125
Stained bamboo	46.0	5800	50.0	105
Decayed bamboo	39.5	4700	32.0	90

The forgoing investigations indicate that both from the point of view of yield of pulp and strength of paper, it is not available to store bamboos for long periods in warm and humid areas or under conditions favourable for decay.

(ii) Decay in Flowered Bamboo and its effect on pulp

In most species of bamboo, flowering occurs only at long intervals and generally with a definite periodicity. This type of flowering is generally gregarious occuring over an extensive area where the flowering may continue for some years. After flowering the culms of bamboo die. Being an organic substrate, a dead bamboo, like any dead tree, is liable to attack by fungi, among which decay fungi are important. Since the starch is utilised during flowering, a flowered and dead bamboo is not usually attacked by insects. During storage in piles, decay progresses rapidly during the rains, where moisture in the bamboo and also temperature conditions as exist in the tropics are ideal for the rapid progress of decay. It is generally held that the yield and quality of pulp are not lowered by using flowered and dead bamboo. The decay is mostly due to white rot in which all components of cell well are consumed. Brown rot, in which cellulose is mainly consumed, constituted a small percentage. Healthy bamboo, bamboo attack with white rot and bamboo attack with brown rot were pulped by the sulphate process and results are given in Table VIII.[6]

In case of white rot, although the bamboo can be used for pulping the following disadvantages are observed:

1. Pulp yield. In moderate decay, there is an appreciable loss of pulp yield per digester as compared to healthy bamboo. In advanced decay, yield of pulp per digester is about the same as in healthy bamboo. This is due to removal of parenchyma at this stage of decay leaving greater percentage of fibro vascular strends which form the main basis for pulp.

2. Loss in strength. The strength properties of pulp prepared from decayed bamboo. are lower than those prepared from healthy bamboo. The presence of bore holes on the fibres explains the reduction in strength properties of pulp obtained from decayed bamboo.

3. Increase in bleach consumption. The permangnate number of unbleached pulps prepared from decayed bamboo is higher than that of healthy bamboo indicating a greater content of residual lignin in pulp from decayed bamboo. These pulps, therefore, requires more bleaching chemicals.

The investigation shows that in the case of brown rot, the yield of unbleached pulp is very low compared to healthy bamboo and that the permanganate number of the pulp is so high that the pulp is unbleachable. This is because the brown rot fungi selectively attack cellulose leaving a high percentage of lignin behind. Bamboo subjected to brown rot is thus unsuitable for pulping. However, incidence of brown rot in bamboo was insignificant.

TABLE VIII

Table—Sulphate digestion of healthy and decayed bamboo, showing yield and strength properties

Specimens		*Unbleached pulp yield* %	*$KMNO_2$ No.*	*Bleach consumption as available chlorine on e.d. pulp* %	*Bleached pulp yield*	*Breaking length* metres	*Burst factor*	*Tear factor*
healthy		42.0	15.2	6.80	34.4	7890	47.5	53.5
	White rot							
	initial	38.0	18.0	8.60	31.0	3630	23.3	51.6
decayed	moderate	43.0	22.3	11.60	38.2	3470	31.4	48.1
	advanced	50.3	20.0	9.36	46.3	3720	23.0	33.0
	Brown rot	17.0	31.0		Unbleachable			

* On raw material (oven-dry).

References

1. Guha, S.R.D., Sharma, Y.K., and Karira, B.G., Storage Experiments on Eucalyptus hybrid (mostly E. teriticornis) Paper submitted in this summer.

2. Guha S.R.D., Man Mohan Singh and Bhola, P.P. *Indian Forester, 101*, 8, (1975).

3. Man Mohan Singh and Guha, S.R.D., *Indian Forester, 91*, 3, (1963).

4. Guha S.R.D., Bakshi, B.K. and Thapar H.S. *17c 72* (1958).

5. Bakshi, B.K., Guha S.R.D., and Gupta, *S. Research and Industry 5*, 2, 38 (1960).

6. Bakshi, B.K. Guha S.R.D., Sujan Singh, Rajesh Pant and Taneja, K., *Indian Pulp and Paper, 22*, 9, 1-4 (1968).