Utilization of Banana Fibre for Making Certain Specialty Paperboards Using Eco-Friendly Processes

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Laboratory scale investigation was carried out for making certain specialty paperboards viz cellulosic leather boards and solid toughen board from mixture of banana fibre and waste paper pulp using eco-friendly processes. Cellulosic leather boards are generally used in footwear industries and solid toughen boards are used as a packaging media. Banana fibres used for the present investigation was extracted mechanically in a fibre respoder. Bleaching of the fibres was carried out using hydrogen peroxide. An enzymatic pretreatment was given to the fibres prior to bleaching in order to remove gummy materials and lignin. The fibres were beaten in a laboratory valley beater up to 45°SR freeness. Similarly, the waste paper was also beaten at the same freeness. Wax emulsion, natural latex and cationic starch solution was added to the pulp stock during the time of beating. Multilayed boards were made in a laboratory hand sheet-forming machine using banana fibre and waste paper pulp at different blend ratio viz 20:80, 40:60 and 50:50 Boards of different thickness varies from 2-5 mm were prepared and pressed in a hydraulic press and then dried in an air circulatory oven at 100±2°C temperature. Board samples prepared in the laboratory hand sheet-making machine were tested. It has been observed that high quality cellulosic leather board with breaking load 120-135 kg, apparent density 1.05g/cc, average tensile strength 250 kg/cm^2 (dry) and 150 kg/cm^2 (wet), tearing strength 10.5 kg/cm, water absorption 98% (24h), having satisfactory fire resistant properties can be made from the waste paper pulp and banana fibre. Likewise, solid toughen boards with 160 kg and 90 kg breaking load (30 & 60 cm span), 10.5% water absorbency and good fire resistance properties can be made from the pulp stock containing 50% banana fibre and 50% waste paper pulp. The process involves no hazards effect and no harmful chemicals were used during the processing of fibres and manufacturing of the boards. It may be concluded that mechanically extracted banana fibre can easily be utilized for making specially paperboard products like cellulosic leather board and solid toughen board. There is substantial scope for use these types of paperboards in packaging and footwear industries.

INTRODUCTION

Pulp and Paper industry is considered to be the highest consumer of forest raw material on global basis. Due to the continuous use of plant raw materials like bamboo, soft wood, hard wood etc, the forest areas covering such plant materials are day-by-day decreasing at an alarming rate. Considering the gradual shortage of conventional cellulosic raw material, emphasis has been given on utilization of new fibrous raw material for the manufacture of pulp, paper, board and other cellulose based products (1,2,3,4, & 5). Unlike paper, the demands of paperboards are also day by day increasing Paperboards are mostly used as packaging media. However, some boards are used for some special purposes. Cellulosic leather boards are used in making bags, suitcase, footwear and allied industries. Substantial quantities of such specialty boards are being imported. The main characteristics of these boards are that they possess high tensile and bursting strength, good water repellency, smooth and easy punchability, good stiffness, high flexing index, high resistance to abrasion and dimensional stability. Likewise, solid toughen board is also a type of specialty paperboard suitable for packaging of machine, tools, food products etc. items(6). Solid toughen board has certain advantages over conventional corrugated fiberboard.

i. Solid toughen boards perform better than corrugated boards under wet or humid conditions.

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It is generally more suitable over corrugated boxes for exporting goods to countries with humid climates or where storage on dock is involved or where the cases are likely to come into contact with water, oil, grease etc.

ii. Solid toughen boards have a greater resistance to puncture than the corrugated ones. Solid boards is therefore more suitable for heavy article that could damage the container on care less handling due to puncture from external objects.

iii. Corrugated boards crush more easily than solid boards. So solid toughen boards are more suitable for use where a high resistance to indentation is needed.

iv. A variety of effective barriers and treatments can be offered with solid fiberboard.

v. The fluting of corrugated boards provide a nice abode for insects, dirt and undesirables wheres solid toughen board is not so accommodating and should be preferred where prolonged storage or re-use is involved.

vi. The contents of a solid case generally freeze quicker than if these are packed in an equivalent corrugated case. Moisture changes during freezing lead to a much more rapid delamination in performance of currugated than solid case.

vii. The heavier grades of solid fibreboards do not ignite as easily as corrugated boards.

Although, various types of packaging media such as timber, plywood, plastics, thermocol etc are extensively used now a days for packaging of different items of day-to-day use. but due to the shortage of wood, the use of timbers and plywoods are gradually restricted. On the other hand plastics, thermocol and other polymeric substances are not biodegradable in nature and as such they caused pollution. Therefore, in recent years, attention has been given to check the pollution load through out the world to maintain an ecological balance utilizing eco-friendly chemicals and technology. Regional Research Laboratory, Jorhat worked on development of certain specialty paperboard from recycled fibre(7). It has already been reported earlier that the pseudostem portion of banana plants gives good quality fibre (8) having adequate physical strength(3). It also possesses very good pulp and paper making properties (9). As the fibre extracted from banana sheath possesses adequate physical strength, an investigation was undertaken to utilize banana fibre in combination with waste paper pulp for making cellulosic leather board and solid toughen boards using eco-friendly processes. The results of the present investigation are presented in this communication.

EXPERIMENTAL

Raw Material

Wild banana plants (Musa velutina) was collected from hilly areas of Arunachal Pradesh and waste paper in the form of press cuttings and office waste are obtained form the market. The foreign materials such as plastics, strings, clips etc. were sorted out prior to used.

Morphological characteristics of banana plant

The morphological characteristics of banana plant (Musa velutina) used for the present work were studied in the filed as well in the laboratory. The different morphological characteristics of the plants are shown in Table1.

Chemical constituents

The chemical constituents of banana sheath (Musa velutina) were studied as per TAPPI standard method (10). The different constituents recorded for banana sheath are presented in Table2.

Extraction of banana fibre

For extraction of banana fibre, the sheaths were opened manually from the stem and washed with cold fresh water. The sheaths were cut into 90 cm length and then air-dried. The sheaths were then passed through a machine i.e. fibre respoder and the

Table 1 : Morphological characteristics of banana plant (M. velutina)

Particular	Banana Plant (M. velutina)
Stem length, cm	350
Stem diameter, cm	20
No. of leaves	7
Length of the leaves, cm	165
No of sheath in stem	12
Diameter of the central core, cm	10
Green weight of the stem, kg	28
Dry weight of the stem, kg	2.24
Fibre yield %	45-48
Average constituents of the plant (% on O. D. basis)	
Sheath	27
Central core	45
leaves	28

Table 2 : Chemical constituents of banana sheath (Musa velutina)

Particular	Banana Plant sheath (Musa velutina)
Solubility(%)	
Cold water	2.75
Hot water	2.85
1%NaOH	26.7
Alcohol-benzene	2.7
Cellulose % (Cross and Bevan)	58.75
Lignin%	16.5
Pentosan%17.5	
Ash%	1.8
α-Cellulose%	55.0
Silica	0.60

Table 3 : Enzymatic pretreatment and bleaching of pulp

Particulars	Banana fibre	Waste paper pulp
Enzyme charged (XU/g)	10	
Time of treatments, min	180	
consistency, %	8	
pH	6.5	
Peroxide stage (Bleaching)		
H_2O_2 %		
Applied	3.0	2.5
Consumed	3.0	2.5
Initial pH	11.6	11.2
Final pH	10.5	10.0
Final brightness of fibre/pulp %		
Control (without enzyme treatment)	56	52
Enzyme treated	62	62
Viscosity cps	12.5	9.7

crude fibres were collected. These were then washed with cold fresh water. The separated banana fibres were then treated intially with an enzyme prior to bleaching. Enzyme treatment removes certain gummy material as well as lignin from fibre. The fibres were then washed with cold water and bleached with single stage hydrogen peroxide solution. The conditions of enzymatic pretreatment and bleaching of banana fibres are shown in Table 3.

Preparation of waste paper pulp stock

The waste papers viz. press cuttings and office wastes were procured from the market. These were then soaked in water for a period of 6 hrs and put into a hydro pulper to defibrate. After 30 min of running, the stock was discharged and put for a single step hydrogen peroxide bleaching. The bleached pulps were washed with cold fresh water and then transferred to a laboratory valley beater. Beating of pulps were continued up to the freeness of 45°SR. 2% natural latex solution and 3% cationic strach were added to the pulp stock during the time of beating. Prior to this, the stock was sized with rosin soap and a wax emulsion. So also, the semi bleached banana fibre was beaten in a laboratory valley beater at 1.5% consistency up to 45ºSR freeness. Banana fibre stock was also prepared using rosin soap, wax emulsion and natural rubber latex.

Microscopic observation of fibres

Both banana and waste paper pulp fibres were observed under scanning electron microscope jeol, Japan at different magnification. The properties of the fibre observed under electron microscope are presented in Plate 1-4.

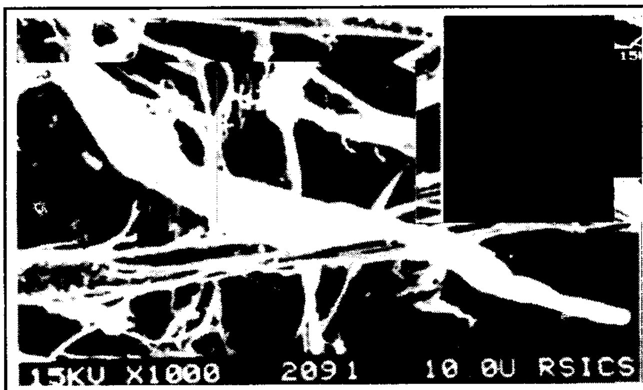

Plate 1 : Banana Fibre

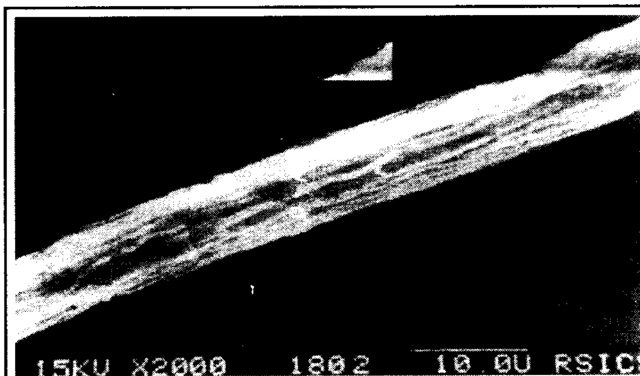

Plate 2 : Scanning electron micrograph of banana fibre

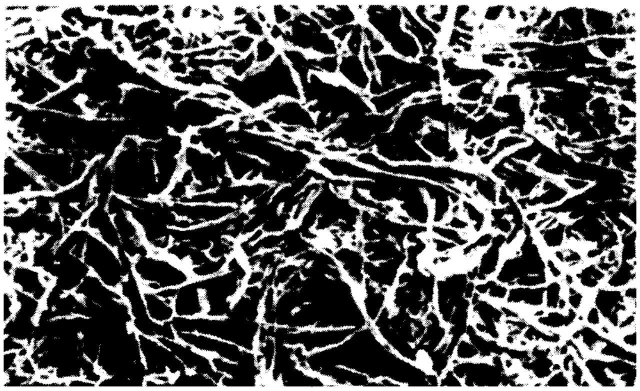
Plate 3 : Waste paper pulp fibre


Plate 4 : Scanning electron micrograph of waste paper pulp fibre

Bleding of pulp stock

Both the pulp stocks were prepared separately and blending was carried out in a laboratory valley beater maintaining the blend ratio at 20:80, 40:60 and 50:50 ratios. The consistency of the stock after blending was measure prior to board making.

Board making

Multi layered boards of different thickness(2-5 mm) were made in the British standard laboratory hand sheet-forming machine. The sheets were then pressed in a hydraulic press, dried in air circulatory oven at 100±2°C. The boards were conditioned at 95±5% relative humidity for 24 h. Solid toughen boards were further treated with a latex solution and rubber chemical to impart better flexibility and higher degree of water resistance.

Table 4 : Physical strength properties of solid toughened boards

Properties	Blend ratio (banana : waste paper)		
	20:80	40:60	10.5
Water absorption (%) (24h)	13.5	12.7	10.5
Weight of sheet (kg) 1x1.5 m sheet	3.82	4.17	4.52
Water percolation test	nil	nil	nil
Breaking load (kg)			
30 cm span	110	145	160
60 cm span	58	75	90
Fire resistance	Satisfactory	Satisfactory	Satisfactory
Delamination	Nil	Nil	Nil

RESULTS AND DISCUSSION

It has been observed from the above investigation that the above specialty paperboards prepared from banana fibre in combination with waste paper pulp fibre gave adequate physical strength. Table 1 & 2 shows the results of the morphological characteristics and chemical constituents of wild banana plant. The important constituents i. e. cellulose and lignin were recorded 58.75% and 16.5% respectively, which is comparable with conventional paper making raw materials (11). The morphological properties showed that the sheath constitutes about 35% of the whole plants and the dry biomass per plant was recorded 2.24 kg. So also, the dry fibre yield was recorded 45-48%. An enzymatic pretreatment followed by single stage hydrogen peroxide bleaching of banana fibre are presented Table 3. It has been observed that the mechanically separated banana fibre contained lignin and gummy materials can be removed to a certain level by an enzymatic treatment prior to bleaching. The conditions of enzymatic pretreatment and single stage peroxide bleaching are shown in Table 3. The electron micrographs of banana fibres are presented in Plate 1 & 2. There were two types of fibres visible under the microscope. Some fibres were narrow and some were comparatively wider. The cell wall of the fibres was distinctly visible (Plate 1). The fibrillar arrangement was almost in linear form. There were occasional void spaces between the fibrils (Plate2). Plate 3 & 4 represents the waste paper pulp fibre under electron microscope. The fibres were flattened with occasional nodes (Plate 3). There were some pores visible inside the fibres. A number crakes were also visible in the fibre sample. The fibrills were not regular in arrangement. The physical strength properties of the solid toughen boards made from the blend of 20:80, 40:60 and 50:50 of banana fibre and waste paper pulp are shown in Table 4. It has been observed that at 50:50 ratio, water absorption values showed minimum

Table 5 : Physical strength properties of cellulosic leather board

Particulars	Laboratory sample	Imported board sample	
		Shank brand	Bontex brand
Apparent density, (g/cc)	1.05	1.0	0.75
Breaking load(kg)	120-135	-	-
Tensile strength (kg/cm²)			
Dry	250	400	227
Wet	150	161	90
Elongation of break, %			
Dry	39	32	110
Wet	23	20	31
Stitch tear strength, (kg/cm thickness)	10.5	4.8	8.7
Water absorption (% by mass)			
30 min	11	41	57
2 h	21	44	60
8 h	35	73	68
24 h	98	101	74
Linear shrinkage, % at 170°C for 1h	3.3	7.0	2.8
Area shrinkage, % at 100 °C for 1h	4.9	8.0	1.2

(10.5%) while breaking load of the sheets recorded maximum 160 and 90 kg at 30 cm and 60 cm span respectively. The water absorption, fire resistance and delamination test showed satisfactory results Table 5 shows the physical strength properties of the cellulosic leather boards made from 50:50 blend ratio of banana fibre and waste paper pulp fibre. The tensile strength of the board samples (dry & wet) was recorded 250 and 101 kg/cm^2 respectively. Which are comparable to the imported 'Shank' brand boards. The elongation of break (%) was found to be 39 (dry) and 23(wet). stitch tear strength (kg/cm thickness) were recorded 10.5 comparable to 'Shank' and 'Bontex' brand boards. The other properties like water absorption (%), linear shrinkage (%) and area shrinkage (%) of the board samples are found to be satisfactory.

CONCLUSION

It may be concluded from the above investigation that banana fibre may easily be utilized for making specially board viz. cellulosic leather boards and solid toughen boards in combination with waste paper pulp. It possesses adequate physical strength properties and can be separated mechanically without the use of any chemicals. It is hoped that, present investigation may lead to the development of indigenous technology for making such specially board products in near future.

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