FUTURE OF HANDMADE PAPER INDUSTRY: SUSTAINABILITY & ALTERNATIVE FIBRES

KNHPI

शिल्प श्रम सनातन

Kumarappa National Handmade Paper Institute

(Khadi & Village Industries Commission)

Ministry of Micro, Small and Medium Enterprises Govt. of India

Recognized by Deptt. of Scientific and Industrial Research Govt. of India

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INTRODUCTION

The Indian paper industry has exhibited a robust annual growth rate of 6–7%, surpassing the global average, particularly in the packaging sector necessitates the exploration and adoption of alternative ligno-cellulosic raw materials.

✓**Sustainability & Environment:** Aligns with sustainable goals

✓**Energy Efficiency:** Non-wood pulping requires less energy

✓**Economic viability:** Significantly reduces cost of production

PINEAPPLE LEAVES & FIBRE AS RAW MATERIAL FOR PAPER MAKING

Botanical name: ***(Ananas comosus)***

GLOBALLY

Major cultivators are Costa Rica, Philippines, Indonesia, China, Brazil and India.

INDIA

- **8% of global production and is 5th largest pineapple producer country.**
- **West Bengal, North east region (Assam, Manipur, Tripura & Meghalaya) and southern states like Kerala .**
- **Production is approximately 1.1 million tonnes for 2025-2026 generating pineapple leaves biomass of 7 to 8 million tonnes.**

Source: *Bhattathiri et al 2025, National Horticulture Board*

YIELD OF PINEAPPLE FIBRE

7 to 8 million tonnes of pineapple leaves ☾ 6.4 lakh tonnes of pineapple fiber

After Harvesting of pineapple fruit, Collection of mature pine apple leaves

Extraction (Decortication with decorticating machine to scrape outer waxy layer and pulp revealing fibres)

Washed and Air dried (6-8% fibre)

- Apparel
- Footwear
- Home Décor
- Vegan Leather

Source: Mazalan et al 2017

PINEAPPLE FIBRE PRODUCTION

SOFT BAMBOO AS RAW MATERIAL FOR PAPER MAKING

- **India bamboo production is approximately 14.6 million tons annually.**
- **North East region shares 40-50% of total production.**
- **The tender bamboo waste available in Kimin, Papum Pare district of Arunachal Pradesh collected.**
- **The soft bamboo waste include:**
  - ✓**soft bamboo shoot**
  - ✓**twigs**
  - ✓**Leaves**

Source: nbm.gov.in, Bamboo Research & Training Centre BRTC

PROXIMATE CHEMICAL ANALYSIS

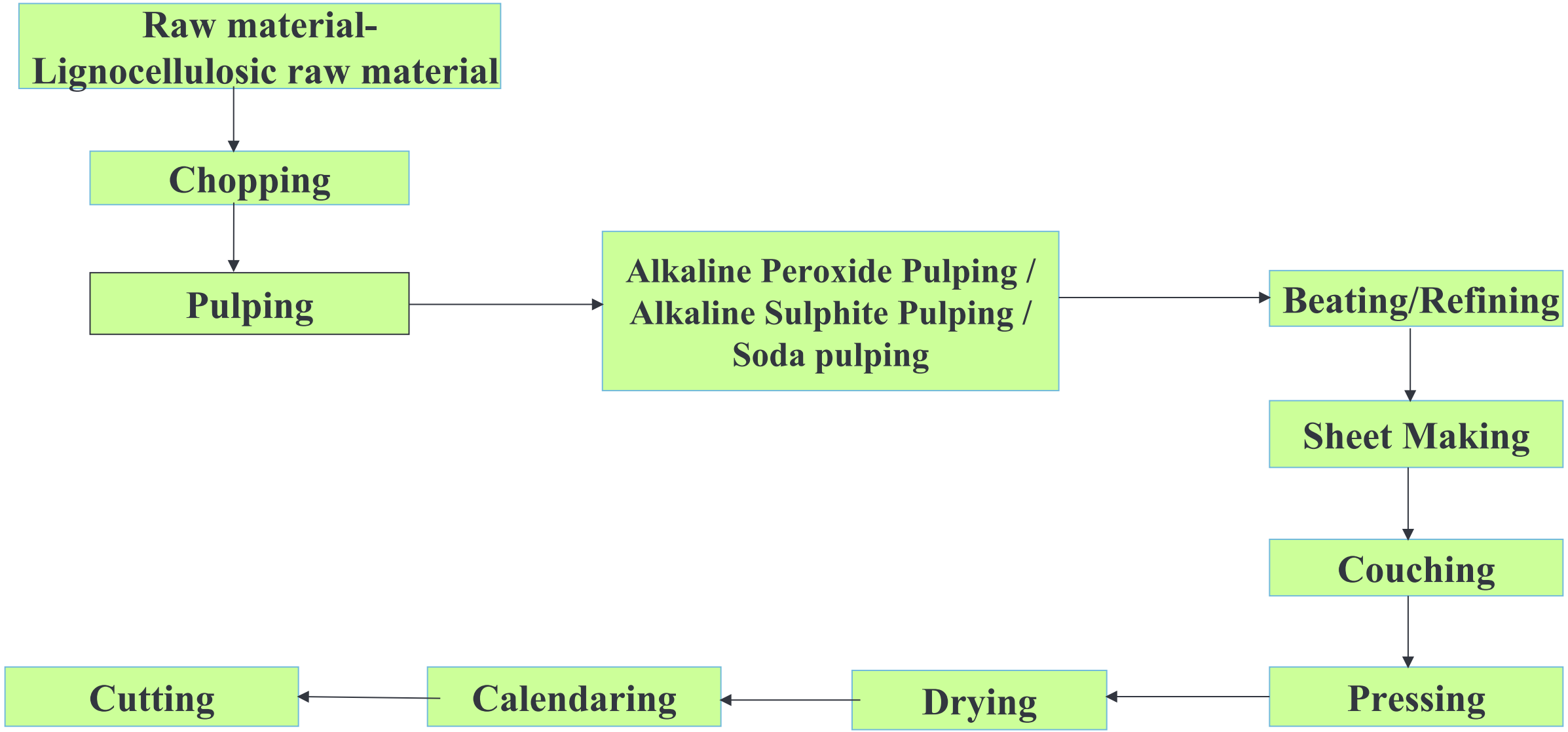
Particulars	Bamboo	Soft Bamboo	Pineapple fibre	Pineapple leaves
Hot Water Solubility,%	4.13	10.03	3.19	26.90
N/10 NaOH Solubility,%	19.5	22.85	18.00	40.73
Alcohol-Benzene Solubility, %	3.48	2.95	14.85	14.90
Ash, %	2.45	4.19	2.25	3.85
Lignin, %	25.20	26.40	9.52	10.87
Holo-cellulose,%	72.78	70.11	84.98	76.54
α-cellulose, %	55.6	41.62	79.95	69.00

FIBRE MORPHOLOGY

Parameters	Pineapple leaf fibre	Soft Bamboo	Lokta	Softwood	Cotton	Hardwood
Fibre Length, mm	9.11	3.00	12	2-4	8	0.5-1.5
Fibre Diameter, µm	28	14.0	22	25-40	20	18-25
Runkel ratio	0.88	1.4	0.42	2	0.54	0.50
Slenderness ratio, L/D	120	22	60	89	40-60	50

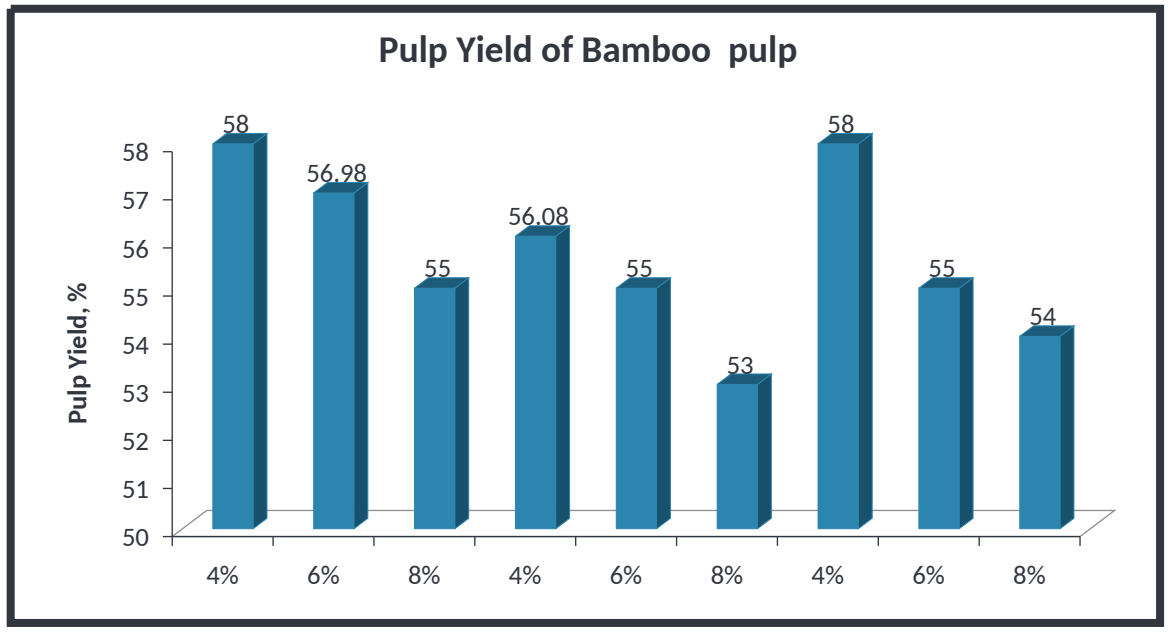
PROCESS OF HANDMADE PAPER MAKING:

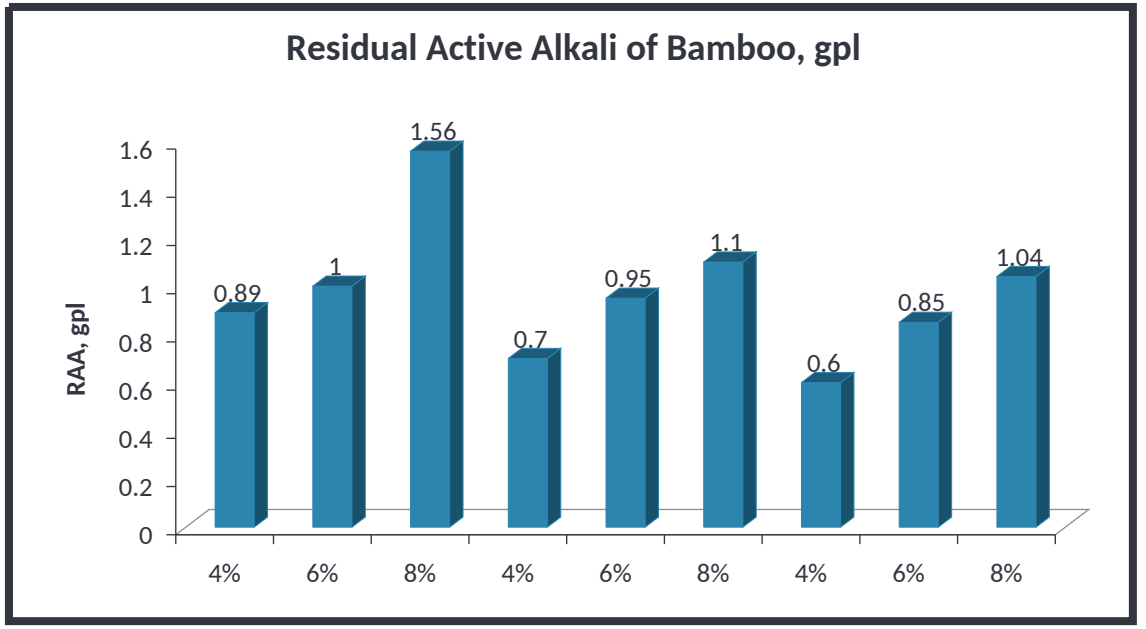
LIGNOCELLULOSIC FIBERS

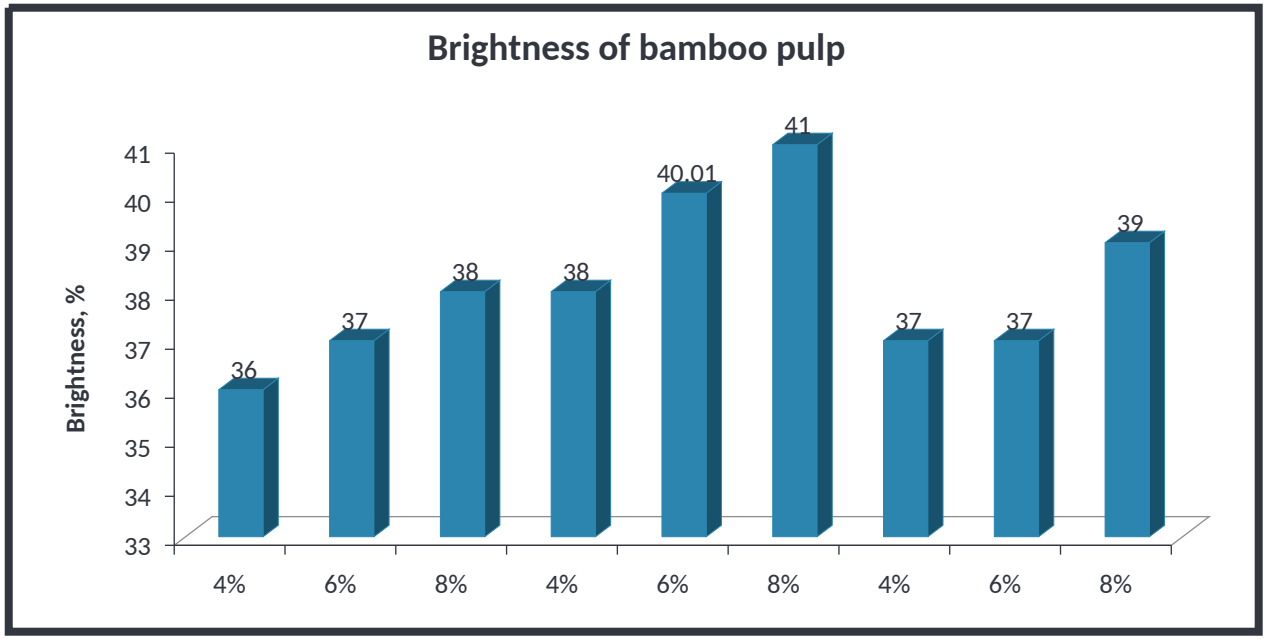


PULPING CONDITIONS AT VARIOUS PULPING PROCESS

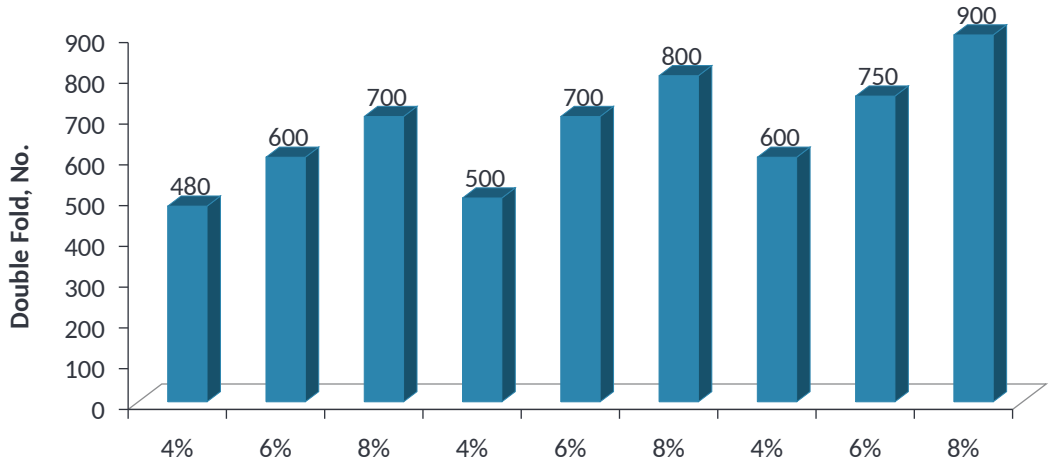
Process	Chemical Dosage	Temperature, ^{0}C	Time, Hours
SODA PULPING	Sodium Hydroxide- 4, 6, 8%	95	3
ALKALINE PEROXIDE PULPING	Sodium Hydroxide- 4, 6, 8 % Hydrogen Peroxide-2%	95	3
ALKALINE SULPHITE PULPING	Sodium Hydroxide (2.8, 4.2, 5.6 %) + Sodium Sulphite (1.2, 1.8, 2.4%)	120	3


Pulp Yield of Bamboo pulp
Pulp Yield, %
58
56.98
55
56.08
55
53
58
55
54
4%
6%
8%
4%
6%
8%
4%
6%
8%

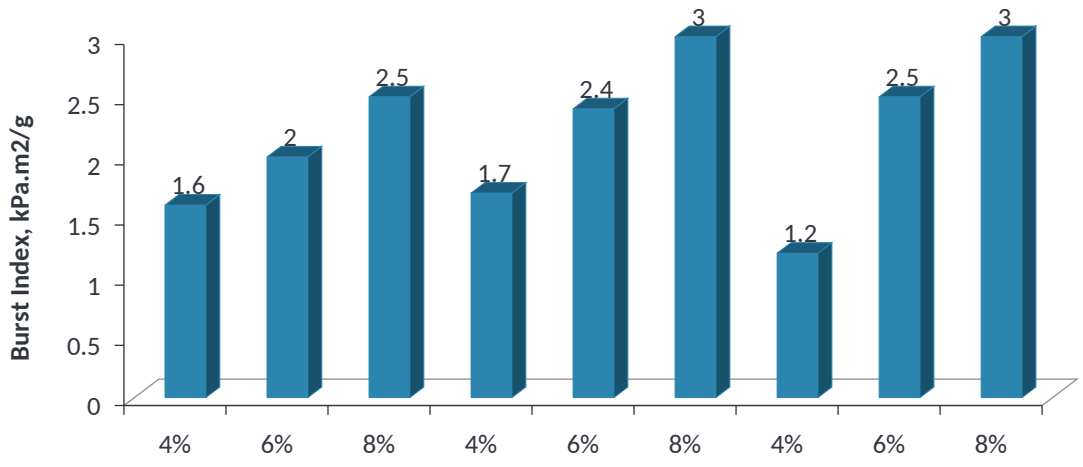

Residual Active Alkali of Bamboo, gpl
RAA, gpl
0.89
1
1.56
0.7
0.95
1.1
0.6
0.85
1.04
4%
6%
8%
4%
6%
8%
4%
6%
8%


Brightness of bamboo pulp
Brightness, %
36
37
38
38
40.01
41
37
37
39
4%
6%
8%
4%
6%
8%
4%
6%
8%

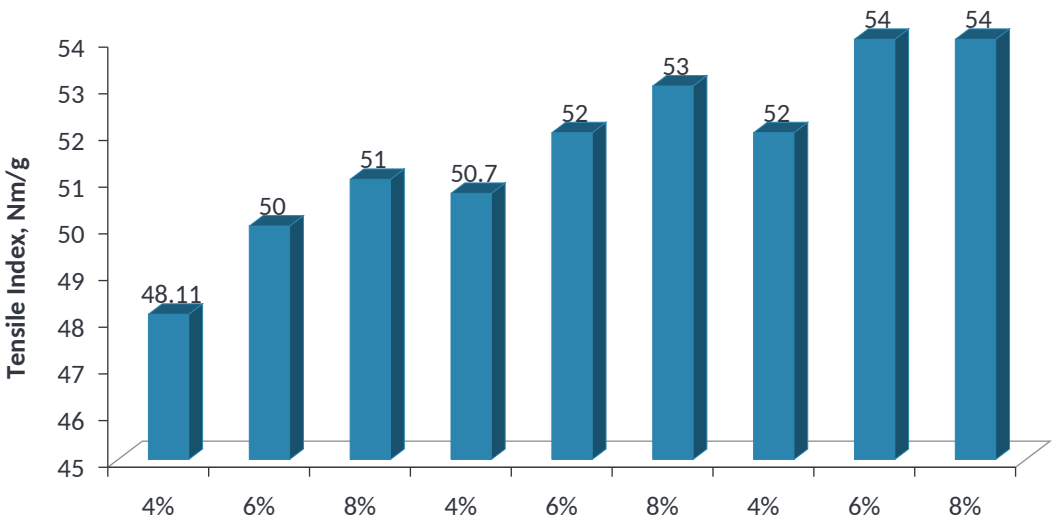
Double Fold of Bamboo pulp



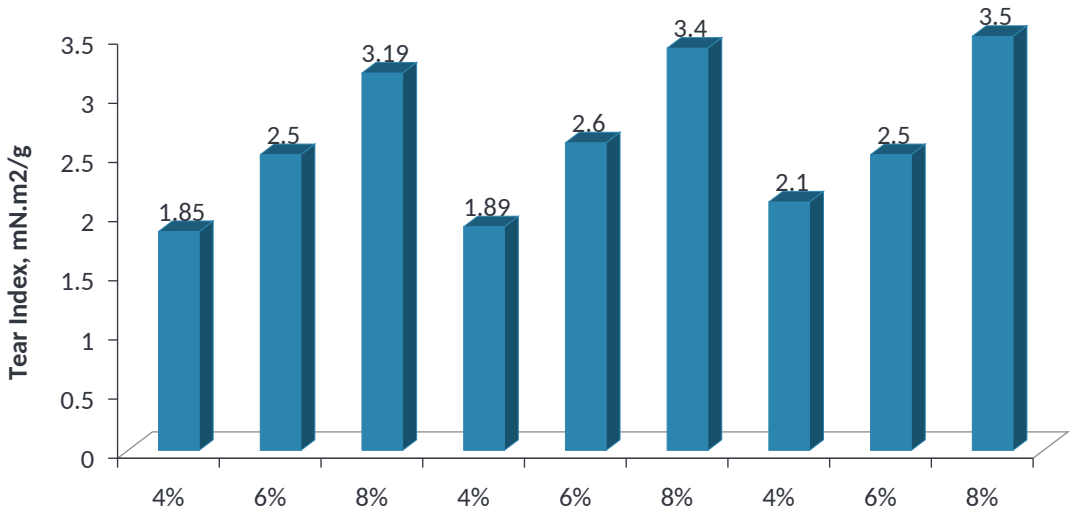
Burst Index of Bamboo pulp

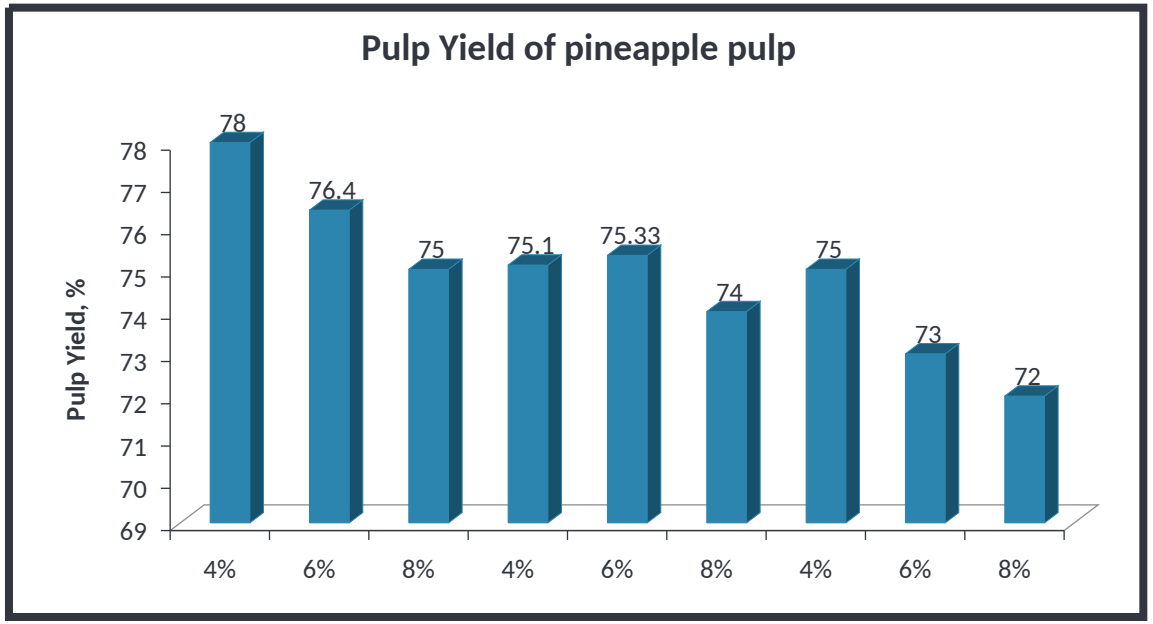


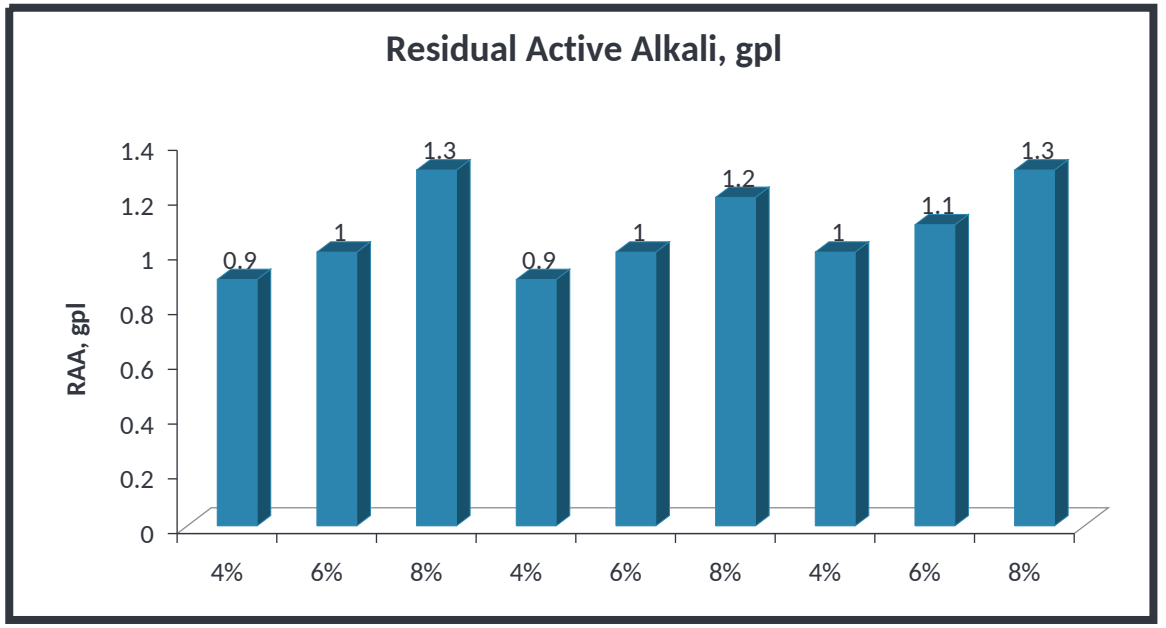
Tensile Index of bamboo pulp

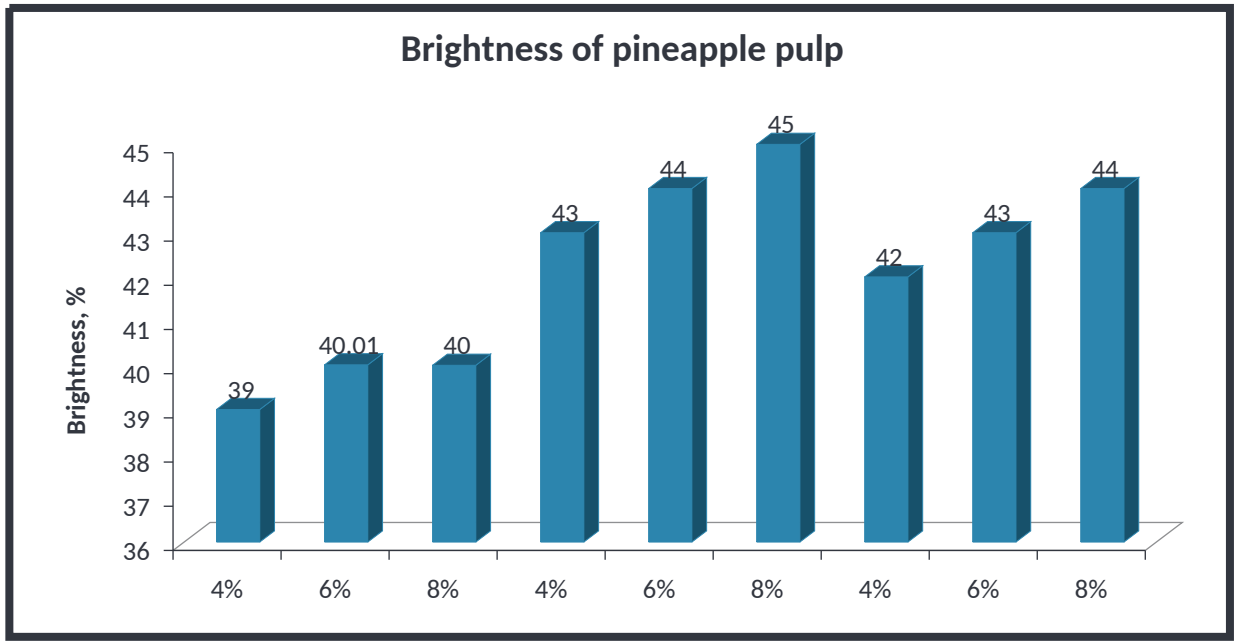


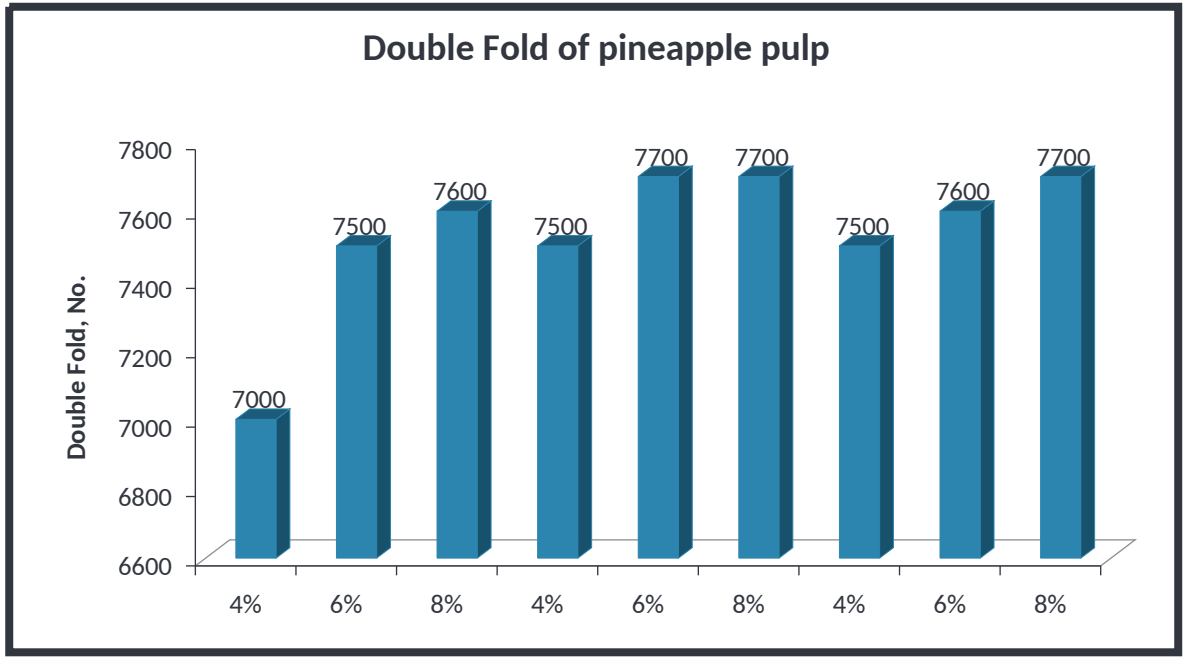
Tear Index of Bamboo pulp

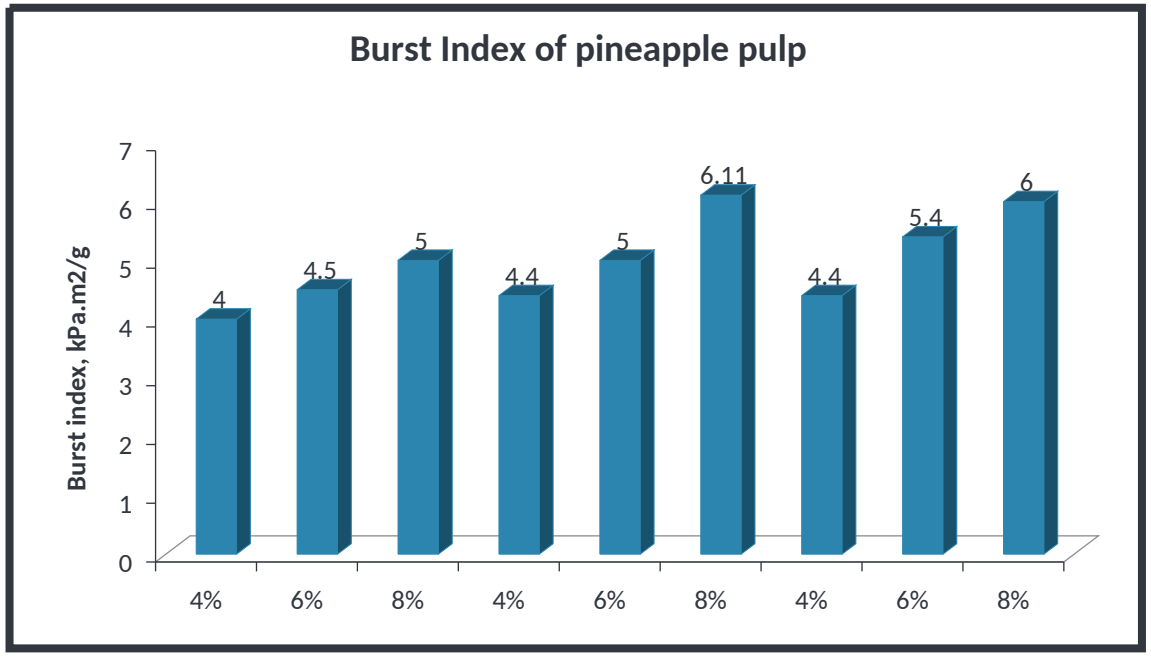


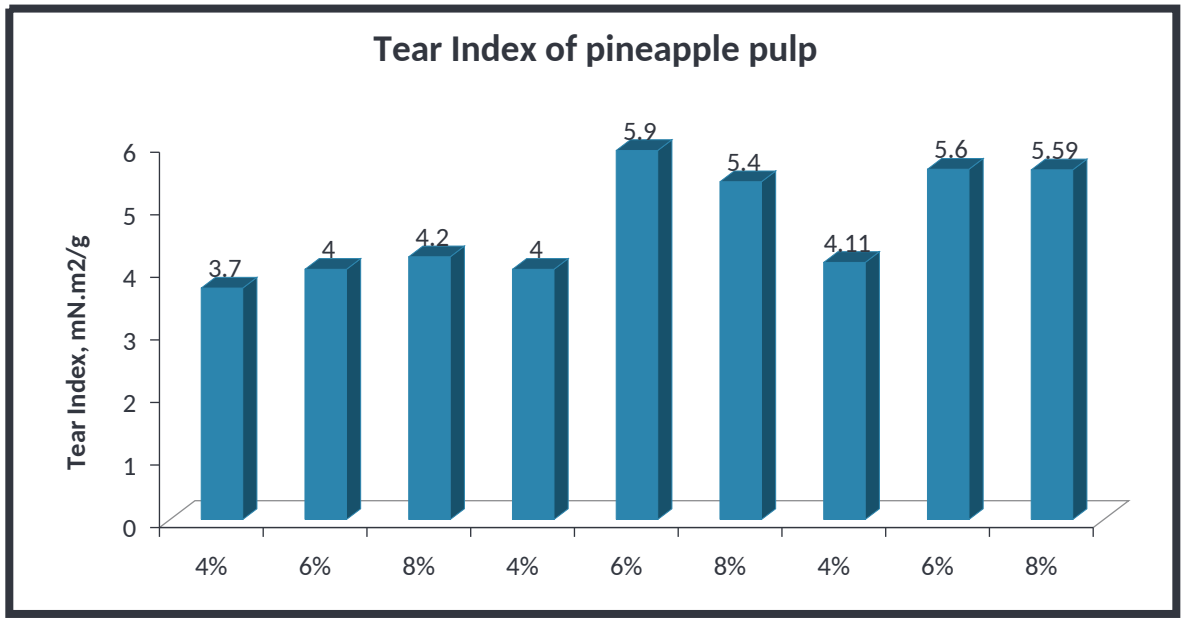

Pulp Yield of pineapple pulp
Pulp Yield, %
78
76.4
75
75.1
75.33
74
75
73
72
4%
6%
8%
4%
6%
8%
4%
6%
8%

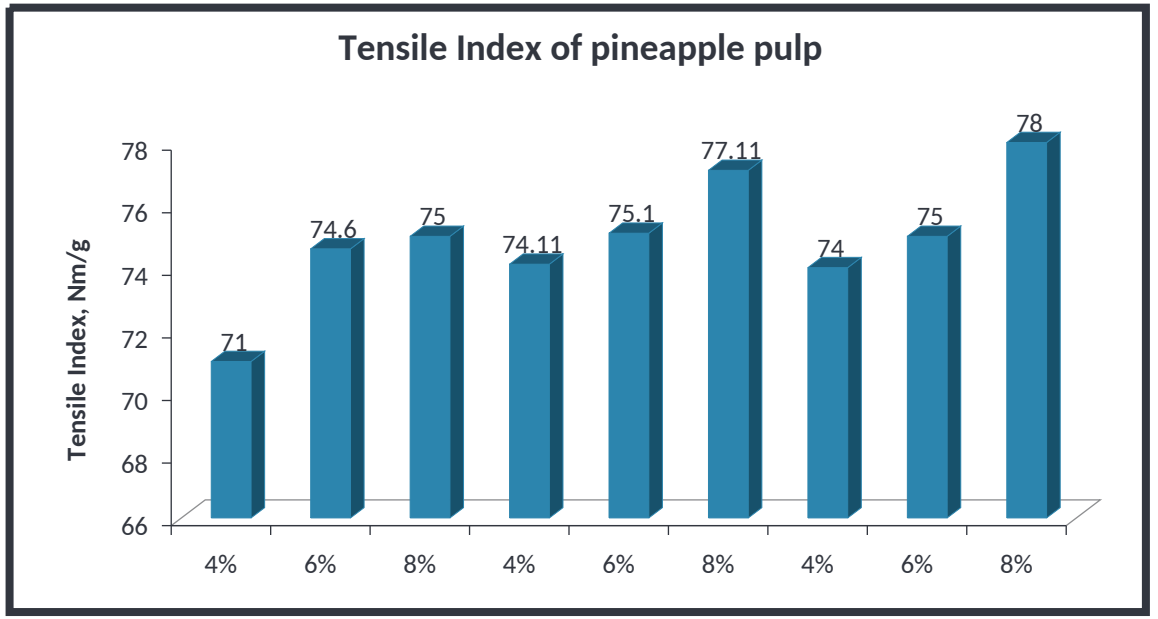

Residual Active Alkali, gpl
RAA, gpl
0.9
1
1.3
0.9
1
1.2
1
1.1
1.3
4%
6%
8%
4%
6%
8%
4%
6%
8%


Brightness of pineapple pulp
Brightness, %
39
40.01
40
43
44
45
42
43
44
4%
6%
8%
4%
6%
8%
4%
6%
8%


Double Fold of pineapple pulp
Double Fold, No.
7800
7600
7400
7200
7000
6800
6600
7000
7500
7600
7500
7700
7700
7500
7600
7700
4%
6%
8%
4%
6%
8%
4%
6%
8%


Burst Index of pineapple pulp
Burst index, kPa.m2/g
7
6
5
4
3
2
1
0
4
4.5
5
4.4
5
6.11
4.4
5.4
6
4%
6%
8%
4%
6%
8%
4%
6%
8%


Tear Index of pineapple pulp
Tear Index, mN.m2/g
6
5
4
3
2
1
0
3.7
4
4.2
4
5.9
5.4
4.11
5.6
5.59
4%
6%
8%
4%
6%
8%
4%
6%
8%


Tensile Index of pineapple pulp
Tensile Index, Nm/g
78
76
74
72
70
68
66
71
74.6
75
74.11
75.1
77.11
74
75
78
4%
6%
8%
4%
6%
8%
4%
6%
8%

CHARACTERIZATION OF SPENT LIQUOR

Parameters	SODA PULPING		ALKALINE PEROXIDE PULPING		ALKALINE SULPHITE PULPING	
	Soft Bamboo 8%	Pineapple Leaf fibre 4%	Soft Bamboo 8%	Pineapple Leaf fibre 4%	Soft Bamboo 8%	Pineapple Leaf fibre 4%
pH	11	9	9.56	9.10	9.50	8.5
Total solids, % (w/w)	1.30	1.05	1.20	0.90	1.40	0.95
Color, PCU	1630	240	1430	210	1320	206
COD, mg/L	6100	840	5310	785	4920	654
COD Load, kg/T	58.63	9.16	50.33	8.55	47.85	7.22

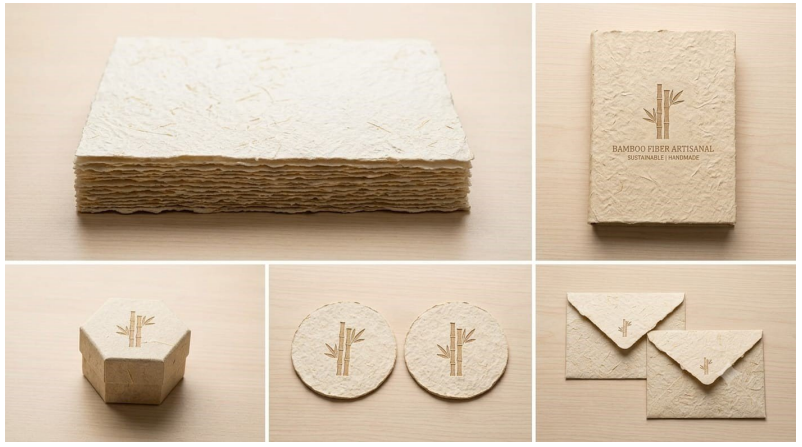
COMPARITIVE PROPERTIES OF PINEAPPLE PAPER

SN	Particulars	Pineapple fibre at alkaline peroxide pulping, 4% Second stage bleaching with Hydrogen Peroxide	IS 1774 Paper for Permanent and Semi-Permanent Records
1	Brightness, %	76	75
2	Opacity,%	87.8	85
3	Tear Index, $mN.m^2/g$	4.81 (587 mN)	500 mN
4	Cobb, gm/m2	20	22
5	pH	7.60	7.5-9.5
6	Accelerated Ageing, years	110	Maximum permanence-Paper is expected to last several hundred years

PRODUCT DEVELOPMENT

SOFT BAMBOO PAPER PRODUCTS

Bamboo HandSheet



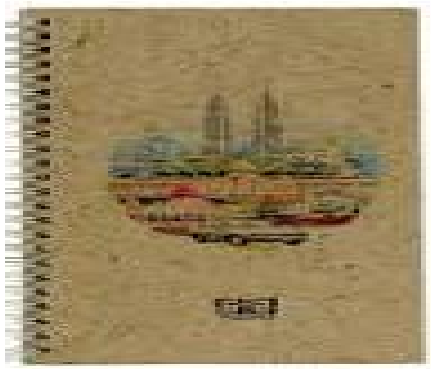
- Shopping Carry bags
- File cover/Folder
- Envelopes
- Molded Products

PINEAPPLE FIBRE AND PINEAPPLE LEAVES PAPER PRODUCTS

Pineapple Leaves
Hand Sheet

Pineapple Fibre
Hand Sheet

Pineapple Tissue paper



POTENTIAL USAGE OF DEVELOPED PINEAPPLE PAPER

- Food grade Biodegradable packaging material for flexible pouches due to inherent high stretch characteristics.

Archival paper due to low lignin and high alpha cellulose content.

- Archival Board (Substitute of ethafoam)
- Archival Tissue paper (up to 123 $)
- Archival Photo Storage Boxes (up to 39 $)
- Heritage album with slip case (up to 100$)

Market Potential and Key Growth Drivers of Archival Paper

Expected Market Growth

Archival paper market was USD 1.2 billion in 2024 which is estimated to reach $1.8 billion by 2033, with a compound annual growth rate (CAGR) of 5.1%

Major Indian users

Sri Aurobindo Ashram
National Archives of India
Indira Gandhi National Centre for Arts
(presently sourcing from Indonesia, Thailand and China)

Export potential

- The United States National Archives,
- The United Kingdom National Archives
- The Myanmar Book Aid Foundation
- University of Yangon
- Purdue University Archives
- University of Central Florida Archives

CONCLUSION

Young entrepreneurs/technocrats in north east region including women will be benefitted in terms of employment.

The developed technology can be immensely helpful for paper industry to utilize pineapple leaves, pineapple fibres and soft bamboo as potential raw material

THANK YOU

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