

# Sweet Sorghum Stalks – An Alternate Agro Based Raw Material For Paper Making

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## ABSTRACT

As the demand for paper products, had increased with economic development of the country, the industries expanded its capacity from time to time. Of late, the paper industry is faced with serious problems due to shortage of raw materials. The problem of finding enough quantities of suitable raw material to meet the increasing demand for paper industry is a continuing one. The main source for the larger mills was forests. Ecological and environmental imperatives dictate that pulp and paper industry should look for alternative raw materials, particularly agricultural wastes which are annual and replenish-able. Indian Paper Industry is primarily dependent on three major raw material sources viz. wood from forests, agricultural residues and secondary fibers. Bagasse and straw were the major non-wood fiber used in most of the mills. Sweet Sorghum stalks found to be available abundantly. This move is not only going to solve environmental problem but also provide unique type of raw material for paper manufacturers. Sorghum has wide adaptability it can be grown in different type of soils. Development of Sweet Sorghum will play an important role in promoting the development of agricultural production and its related products, paper making etc. This paper deals with the use of Sweet Sorghum as an alternate raw material for papermaking. Pulping and bleaching studies were carried out and results were compared with Bagasse. The experiment results prove that the sweet sorghum stalks are found to be better raw material source for papermaking.

**Key words:** *Alternate Agro-residue, papermaking; Physical, chemical and strength properties;*

## Introduction

The Indian Paper Industry is among the top 15 global players today, with an output of more than six millions tons annually with an estimated turnover of Rs. 150,000 millions. Paper industry in India is riding on a strong demand and on an expanding mood to meet the projected demand of 13 million tons by 2020. Per capita, paper consumption has increased to 9.18 kg in 2009-2010 as against 8.3 kg during 2008-2009. Even though there is a rise in per capita consumption, it is still low while compared to China (42 kg) and developed countries (350 kg). With the expected growth in per capita consumption of paper to 20kg by 2020, paper making raw materials have become more of concern to all Paper and Board mills. Paper industry in India is highly fragmented industry. This can broadly be categorized into three segments namely wood, agro residue and waste paper based. Presently the production scenario of paper is 32% from agro residue pulp, 38% from recycled waste paper & secondary fibers and the remaining 30% from wood/bamboo pulps.

Fast depletion of the natural forest in the country has resulted in acute shortage of forest based raw materials, for the paper and newsprint industry. Because of short supply of wood and bamboo, the agricultural residues have gained importance. Wheat straw, Rice straw, Bagasse and other Grasses are being used by the Indian paper industry, helping for an eco friendly environment. Wheat straw, being regular cattle feed, not available sufficiently. Rice straw is not preferred for large and medium mills because it poses problem in recovery unit due to its high silica content (6-15%). Bagasse is a proven raw material for both types of mill i.e. with or without chemical

recovery units. It also gives little difficulties in handling, depithing and storage operations. Efforts by Government of India, to make sugar mills to produce electricity via cogeneration is expected to ultimately also create shortage of bagasse for paper making units. The main sources, particularly for the larger mills, are only forests. Ecological and environmental imperatives dictate that pulp and paper industry should look for alternative raw materials, particularly agricultural wastes which are annually replenishable. Increasing concerns for future fiber supplies and potential increases in wood cost also have strengthened the pulp and paper industry's interest in alternative fiber sources.

By considering the above facts, sweet sorghum may be considered as an alternative raw material preferably in alcohol-paper complex. This paper deals with the use of Sweet Sorghum stalks as an alternate raw material for papermaking. Studies were carried out to understand the potential of fiber properties viz pulping and bleaching and results were compared with Bagasse pulp characteristics.

## About Sweet Sorghum

Sweet sorghum (sorghum bicolor-L Moench) is the only crop that provided grain and stem that can be used for sugar, alcohol, syrup, jaggery, fodder, fuel, bedding, fencing, paper and chewing. Sorghum is one of the most important cereals of the semi arid tropics of the popularly called "poor man's food". India is the second largest sorghum grain producer. Loam and sandy loam soils are the best for the growth of sweet sorghum. However most of the well drained Silt loams will produce excellent sweet sorghum when properly fertilized.

with 13% alkali concentration( as Na<sub>2</sub>O) with temperature of 165°C. The Pulping results such as kappa number, **pulp yield, brightness and black liquor** analysis were analyzed as per

Hybrids of this sorghum giving high yield of good quality grain while retaining the characteristics of juicy stalks high in sugar. The technology of producing pulp from sweet sorghum stalks also developed. Sweet sorghum was also tested in existing paper mill to assess its suitability for paper manufacture. The fibre content in the stalk will be useful to paper industry. The stem of sorghum ( stalks) contains 14-18 % cellulose. Contain high density of fibre ranging 0.8 to 1.6 microns in length and the diameter between 30-60 microns. It is having short fibre length with high proportion of fines.

Table - 1  
Physical Characteristic

S.No	Particulars	Unit	Sweet Sorghum Stalks	Depithed Bagasse
1.	Bulk density	Kg/m <sup>3</sup>	90	80
2.	Useful fibers	%	64.0	63.0
3.	Pith content	%	23.0	26.5
4.	Water soluble	%	13.0	10.5
5.	Fiber to pith ratio	-	2.78 : 1	2.38: 1

Sweet sorghum has been noted for its potential as an energy crop. Unlike sugar cane, which is a tropical plant, sweet sorghum can be cultivated in nearly all temperatures and climate areas. After the extraction of juice, the stalks can be used in papermaking, since it has got better fiber. It has been reported that pulp of sweet sorghum can be used for the manufacture of fine quality writing and printing paper as well as corrugated and solid particle board. The only problem envisaged the paper mill is suitable handling.

Table 2  
Proximate Analysis

S.No	Particulars	Unit	Sweet Sorghum Stalks	Depithed Bagasse
1.	Ash	%	2.8	2.7
2.	Hot Water Solubility	1 %	10.1	9.0
3.	NaOH solubility	%	32.4	31.0
4.	( A-B) Extractives	%	2.8	2.2
5.	Acid insoluble Lignin	%	17.4	20.0
6.	Pentosans	%	27.3	19.0
7.	Hollo cellulose	%	67.2	69.0

### Objective Of This Study

At present after the extraction of juice, the stalks of Sorghum are being used for energy production. Since it has got better fiber value, it has been reported that pulp of sweet sorghum can be used for the manufacture of fine quality writing and printing paper as well as corrugated and solid particle board. To understand the fiber potential in Sweet Sorghum stalks for papermaking. Pulping and bleaching studies were carried out and results were compared with Bagasse.

Table - 3  
Pulping Results of Sorghum and Bagasse

S.No	Particulars	Unit	Sweet Sorghum Stalks	Depithed Bagasse
1.	Chemical addition as Na <sub>2</sub> O	%	12.0	12.0
2.	Bath ratio	-	1:4	1:4
3.	Cooking Temp	° C	165	165
4.	Cooking Time	Min	20	20
5.	Total yield	%	53.5	52.0
6.	Screen rejects	%	1.0	0.8
7.	Screened yield	%	52.5	51.2
8.	Kappa number	%	10.5	11.8
9.	Brightness	%	40.5	41.0

### Material and Methods

Sweet sorghum stalks samples were received from Forest College and used for this study. These sorghum stalks were cut into small pieces and completely soaked with water for 24 hrs, washed, air dried and used for further studies. The washed sorghum stalks were subjected to proximate analysis and pulping experiments. The pulping experiments were carried out at standard pulping conditions which are similar to Bagasse pulping.

Table - 4  
Weak black liquor characteristics of sorghum and bagasse

S.No	Particulars	Units	Sweet Sorghum Stalks	Depithed Bagasse
1.	pH	-	11.6	11.8
2.	Total solids	gpl	188	186
3.	Viscosity at 80o C	Cps	4.4	4.2
4.	TAA at 200 gpl	gpl	28.4	29.3
5.	RAA at 200 gpl	gpl	4.27	4.58
6.	Silica as SiO <sub>2</sub>	%	2.2	2.0
7.	Inorganics as NaOH	%	32.5	33.3
8.	Gross Cal Value	K.Cal/Kg	3260	3200

### Physical and Chemical Analysis

The physical characteristics such as bulk density, basic density and Proximate analysis results such as moisture, ash, hot water solubility, one per cent NaOH solubility, Alcohol-Benzene extractive, Acid insoluble lignin, pentosans, hollocellulose were performed as per TAPPI methods and presented in **Table-1&2**.

Table - 5  
Bleaching Results of sorghum and bagasse

Particulars	Units	Sweet Sorghum Stalks	Depithed Bagasse
Bleaching sequence	-	D <sub>0</sub> EOPD <sub>1</sub>	D <sub>0</sub> EOPD <sub>1</sub>
Total chlorine as ClO <sub>2</sub> applied	%	2.0	2.0
Total chlorine as ClO <sub>2</sub> onsumed	%	1.85	1.90
Total caustic applied	%	1.50	1.50
Total caustic consumed	%	1.02	0.98
Total H <sub>2</sub> O <sub>2</sub> applied	%	0.50	0.50
Total H <sub>2</sub> O <sub>2</sub> consumed	%	0.48	0.47
Final Pulp Brightness	% ISO	88.0	88.5
Final pulp Viscosity	cPs	18.8	18.0
Bleaching loss	%	3.8	3.9

### Pulping

The pulping experiments were carried out in Rotating digester by taking 1000 gm OD stalks

TAPPI standard method. The results are given in **Table-3**. Weak black liquor characteristics are presented in **Table-4**.

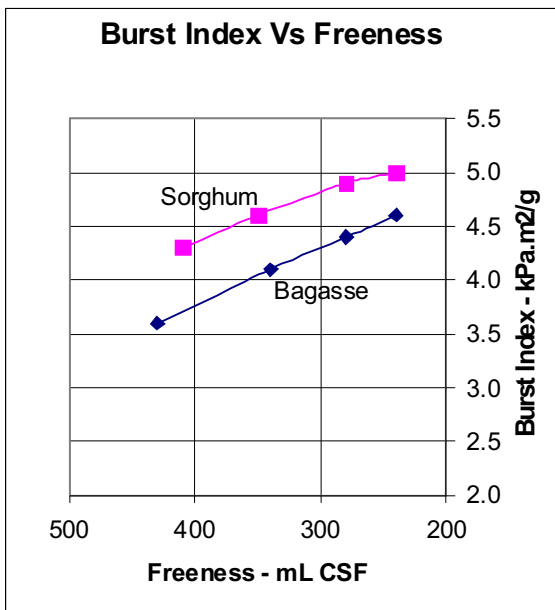
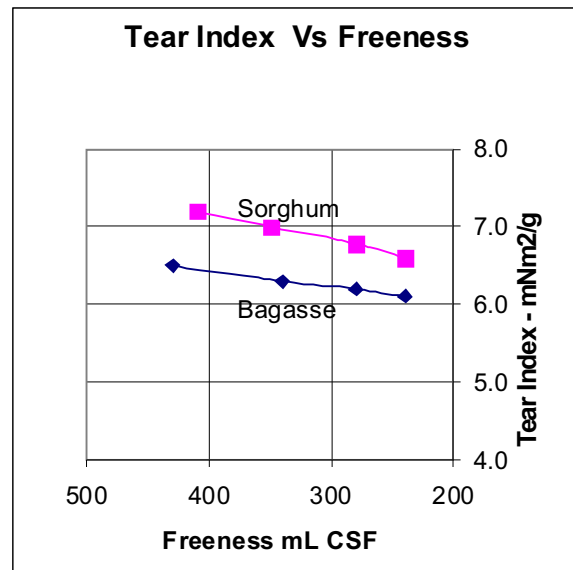
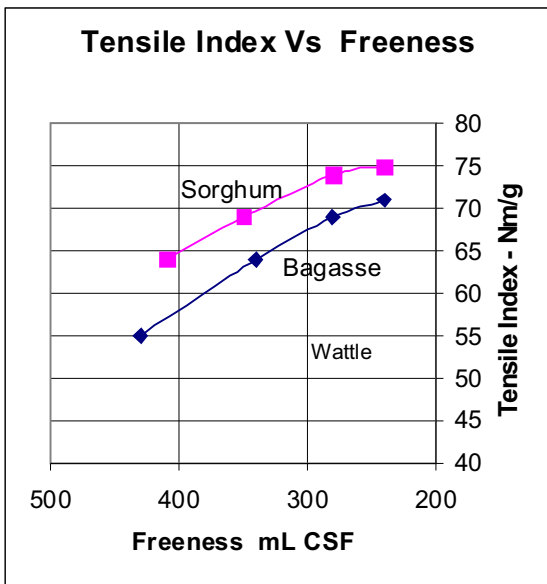
**Bleaching**

The Bleaching studies were carried out with ECF bleaching sequence (Do EOPD1) for obtaining the pulp brightness level of 88 % ISO and pulp strength properties were evaluated at different freeness level by using PFI mill for refining. The strength properties at 300 ml CSF were computed and presented in Table- 5 & 6.

Table 6  
Bleached pulp properties of sorghum and bagasse

S.No	Particulars	Units	Sweet Sorghum Stalks	Depithed Bagasse
1	Bulk	Cc/g	1.55	1.50
2	Brightness	% ISO	88.0	88.5
3	Opacity	% (ptg)	83.0	81.0
4	Sc. Coefficient	m <sup>2</sup> / kg	32.0	29.0
<b>STRENGTH AT 300 ml CSF</b>				
5	Tensile index	N m <sup>2</sup> / g	73.0	68.0
6	Tear index	mN m <sup>2</sup> /g	6.8	6.2
7	Burst index	Kpa. m <sup>2</sup> /g	4.8	4.3

**BLEACHED PULP STRENGTH PROPERTIES AT VARIOUS FREENESS LEVEL OF SORGHUM STALKS & BAGASSE**



**STRENGTH AT 300 ML CSF**

	Sorghum	Bagasse
Tensile Index	73.0	68.0
Tear Index	6.8	6.2
Burst Index	4.8	4.3

## Results and Discussion

The physical characteristics of Sorghum stalks and bagasse show that the bulk density of sorghum is comparable with bagasse. The pith content of sorghum is slightly less when compared to bagasse. The pith content of whole bagasse (undepithed) is around 30 - 35% where as the same in undepithed sorghum stalks is only 22-25%. The proximate analysis indicate that the lignin content of Sorghum stalks is lower than that of bagasse. Caustic solubility is higher for sorghum stalks. Ash and A-B extractives are similar in both cases.

Pulping results reveal that the total pulp yield is slightly higher for sorghum when compared to bagasse at same chemical addition. The similar Kappa number of the pulp shows that the chemical requirements in both cases are same. Effective utilization of these two species in the paper industry individually will lead to the profitability of the mill.

Both black liquors are having more or less similar properties. This shows good concept of using WBL in soda recovery plant with less investment or we can readily utilize the available SRP for further processing of either bagasse or sorghum WBL's independently or jointly.

Bleaching results indicate that the response of both sorghum and bagasse is almost similar. The bleaching chemical requirement to obtain 88% brightness level is almost same in both cases. Shrinkage during bleaching is similar in both raw materials. Strength properties of bleached pulp at various freeness levels and computed at 300 ml CSF indicate that, the strength of sweet sorghum pulp is slightly better than that of Bagasse.

## Conclusion

Sweet sorghum and bagasse are having similar bulk density which may not have any variation in pulping process and the same digesters can be utilized. Sorghum is having less pith

content when compared to bagasse and thus gives better yield with higher strength properties. Considering all physical, chemical and strength properties, Sweet sorghum stalks subjected for analysis were found to be suitable as a source of alternate agro based Raw material for paper making. However, considering the pulp yield and kappa number coupled with strength properties, the superiority of the Sweet sorghum stalks over the bagasse is an alternate source is evident and hence the Sweet sorghum stalks after extraction of juice is recommended as an alternate agro-based raw material for papermaking. The juice extracted can be subjected to biomethanation process for generation of biogas.

## Reference

- 1) Joint text book committee of paper industry VOLUME 1 & 2.
- 2) Pulp and paper chemistry and chemical technology JAMES CASEY VOLUME 1
- 3) Sweet sorghum bagasse as raw material for paper making S.S.Rao-Jowar Samachar volume 6 No:1-Feb 2010 NRCS-Hyderabad.
- 4) Sweet sorghum: A quality raw material for the manufacture of paper. Biomass and Bioenergy volume VIII issue 6-1995.
- 5) Indian paper industry growth and prospects IPPTA Jan18(2).
- 6) Pulp and paper chemistry and chemical technology James Casey Volume I Page No 529
- 7) A.K.Rajvanhi and N.NIMBKAR - sweet sorghum R & D studies at Nimbkar agriculture research institute (NARI).

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