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AN INTEGRATED APPROACH FOR UTILIZATION OF RICE STRAW FOR PRODUCTION OF VARIOUS GRADES OF PAPER





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Abstract :

Rice being the most cultivated crop in all over the world is also an abundant source of fiberin the form of rice straw left after separating the rice grains from plant. Like wheat straw Rice straw also has paper making cellulosic component in substantial proportion. Unfortunately use of rice straw in Indian Paper Industry could not be explored on larger scale like wheat straw because of the presence of high amount of silica which causes severe problem in processing for pulp and paper.

Considering the availability of rice straw, scarcity of paper making fibers in India and the air pollution due to incineration of residual rice straw in agricultural fields the efforts have been made to explore the various pulping, bleaching, paper and board making prospects of rice straw.

The pretreatment of rice straw makes it clean and for production of bleachable grade pulp, with mixed pulping of rice straw with other agro-residual raw materials is also an alternate approach for utilization of rice straw. With growing market of packaging paper and board there is again a vast scope for utilization of rice straw for production of semi-chemical or mechanical grade pulp for these grade of paper and board.

The present communication is focused on utilization of rice straw under different process so that a green production by this cellulosic waste could be turned out in value addition vis-a-vis reduction in air pollution and control on release of greenhouse gases.

Keywords :

Keywords: Rice straw, pretreatment, blending, chemical pulp, semi-chemical pulp'

INTRODUCTION

Rice straw is a by-product of rice production and a great bioresource. It is one of the abundant lignocellulosic waste materials in the world. It is the largest amount from a single biomass feedstock. Rice straw predominantly contains cellulose 32-47%, hemicelluloses 19-27%, lignin 5-24% and ashes 18.8%. Higher percentage of silica in rice straw (5-15%) is the biggest draw back due to which this abundant source of cellulosic fiber has not been properly utilized in paper making at larger scale (1-2)

In the past, disposal of straw by burning was an accepted practice. This practice is now being challenged due to concern over the health effects of smoke from burning fields. In these waste products, the polysaccharides, cellulose and hemicellulose are intimately associated with lignin in the plant cell wall. The lignin component acts as a physical barrier and must be removed to make the carbohydrates available for further use.

Bioconversion of cellulosic biomass into fermentable sugar, for production of ethanol using microorganisms, especially cellulose degrading fungi, makes bioethanol production, environmental friendly. In case of alcohol production it is then subjected to hydrolysis, therefore, the pretreatment is a necessary process for utilization of lignocellulosic materials for fuel production. A number of laboratory and pilot scale studies have been reported on utilization of rice straw in bio refinery and production of bio fuel (2-4). So far no commercial plant on rice straw based bio refinery came in notice. The economic viability of these plant is the biggest question for commercialization of the technology.

Among the Indian states major states which produce rice straw are West Bengal, Chhattisgarh, Uttar Pradesh, Punjab, Andhra Pradesh and Uttarakhand. Only

in Punjab paddy is cultivated in 2.8 million hectares in the state and generates about 20 million tonnes of paddy straw every year. Paddy which are harvested mechanically, leaving considerable stubble in the field, which is then burnt by farmers to prepare their farms for the next crop. This practice results in considerable emissions such as particulate matter and black carbon, and in the loss of soil micro-organisms. It is also important to note that most of medium and small scale mills based on agrobased raw materials are situated in UP, Uttarakhand and Punjab. In order to combat the problem The 'Policy for Management and Utilization of Paddy Straw in Punjab' was approved by the Punjab Government, in October 2013. Hence there is a very strong need of alternate approach for utilization of paddy which is both economic and environment friendly.

Efforts are made in present studies to address both supplements to the shortage of paper making fiber and control of incineration and air pollution by providing integrated approach of utilization of rice straw.

EXPERIMENTAL :

Characterization of Rice Straw:

Cellulosic fibercharacterization involved determination of its proximate chemical composition. Proximate chemical composition included the evaluation of following parameters: ash (TAPPI T 244 cm-99); cold and hot water solubility (TAPPI T 207 cm-99); 0.1 N NaOH solubility (TAPPI T 212 om-02); alcohol benzene solubility (TAPPI T 204 cm-97); holocellulose (TAPPI T 249 cm-00); and acid insoluble lignin (TAPPI T 222 om-02). A certain quantity of rice straw was converted into 100 g of dust having mesh size 40 using the laboratory dust making machine. Samples for proximate chemical analysis were taken in a way that they represented the whole of the material and were in a suitable form to react with the reagents employed.

Pulping Experiments:

Pulping experiment was carried out in laboratory series digester with the objective to optimize the cooking chemical with varying dosage in order to obtain unbleached pulp kappa number at desirable level for production of chemical grade pulp. At the end of the cooking, the bombs were removed and quenched in the water tank to depressurize. The cooked mass from each bomb was taken for washing on a laboratory flat stationary screen with a 300-mesh wire bottom. First, the washing was carried out with hot water till the cooked mass was free from spent liquor. After that, the slurry of washed cooked mass wasdisintegrated using motorized rotary bucket disintegrator. The disintegrated cooked mass was thoroughly washed and pressed to obtain air dried cooked pulp. After thorough washing, the air dried pulp was screened in laboratory screen using mesh of 0.25 mm slot width to remove the rejects.The identical cooking condition was maintained throughout the studies. Unbleached pulp was characterized for the following:

Table 1: Chemical Composition of Rice straw collected from different Sources

S. No.	Parameters	Method
1.	Kappa number	TAPPI T 236-OS-76
2.	Pulp Viscosity	SCAN C 15 : 65
3.	Total pulp yield	-
4.	Screened pulp yield	-
5.	Pulp rejects	
6.	Pulp brightness	ISO 2469

RESULT AND DISCUSSION

Proximate Chemical Analysis:

The chemical composition of rice straw collected from different regions is cited in table 1. The analysis of various parameters like ash, silica, acid insoluble lignin and holocellulose indicates that silica is highest in Chhattisgarh paddy followed by Punjab West Bengal and Uttar Pradesh.Silica which is not a good component for overall process need to be removed or minimize.

Parameters,%	Chhattisgarh	Punjab	West Bengal	Uttar Pradesh
Ash	17.28	16.17	14.47	14.20
Silica	10.29	8.92	7.15	6.95
Acid insoluble lignin	16.51	15.02	13.96	13.55
Holocellulose	53.11	-	58.62	55.96

Holocellulose percentage is comparable to other otheragrobased raw materials.it ranges from 53 to 59% by composition in different samples of rice straw. The lignin ranges from 13 to 16.5% which is substantially low as compared to wood based raw materials.

2. Chemical Pulping of Rice straw:

Soda AQ pulping is common pulping process which most of the open structured agro-based raw materials follow for production of chemical grade pulp. A two stage pulping process was carried out applying methanol as pretreatment agent the results are shown in Table 2.

Soda pulping of rice straw is with and without pretreatment was carried out and it was observed a substantial gain in unbleached pulp yield from 51.04% of blank to 59.31%with alkali methanol pretreatment. Substantial drop in unbleached pulp kappa number from 16.0 of blank to 11.5 for pretreated rice straw is also observed. Similar trend is

Table 2 Results of Soda Pulping of Rice Straw

Pre-treatment Stage	Blank	Run 1	Run 2
Chemical app.,% (Alkali as NaOH/Methanol)	--	2/2	2/4
Pulping			
Alkali applied as NaOH,%	10	8	8
AQ dosage,%	0.05	0.05	0.05
Bath Ratio	1:5	1:5	1:5
Pulp Yield, %	51.73	54.51	61.20
Screened Yield, %	51.04	52.50	59.31
Screen Rejects, %	0.70	2.01	1.89
Kappa Number	16.0	12.45	11.50
Viscosity, cm^3/g	663.19	775.5	750.4

also observed for viscosity of unbleached pulp too.

3. Mixed Pulping of Rice straw and other Agrobased Raw materials like Bagasse and Wheat Straw:

Like chemical composition cooking conditions of rice straw is also similar bagasse and wheat straw. Being seasonal crops during the year, the shortage is over there of one agro based raw material. in order to overcome with this problem Most of the mills based on agrobased raw materials also practicing mixed pulping i.e wheat straw along with bagasse.the experiments of mixed pulping of rice straw with bagasse and wheat straw were carried out. The results of same are depicted in table 3 and 4

4. Semi-Chemical Pulping of Rice Straw for production of Packaging grade Paper and Paper Board

Rice straw semi chemical grade pulp produced with mild cooking conditions (3% soda at 120oC) resulted into pulp of low physical strength as shown in Table 6.

The OCC pulp prepared in laboratory hydra pulperwas subjected to blending with virgin fibersof rice straw soda pulp to make handsheets of 80 g/m2 basis weight. The OCC pulp was blended with rice straw pulp at 5 intervals ranging from 0 to 100%. It was observed that blending OCC with rice straw pulp enhanced the freeness of the rice straw virgin fiber.

Table 3: Result of Soda pulping of Rice straw and Bagasse

Parameters	1	2
Rice straw :Bagasse Ratio	50:50	70:30
Alkali charge% (as NaOH)	16	14
Bath ratio	1:5	1:5
Unscreened pulp yield, %	51.2	53.4
Rejects, %	0.48	0.54
Screened pulp yield, %	50.7	52.8
Kappa number	18.2	14.5
Pulp brightness, % (ISO)	29.1	27.7
Pulp viscosity, cc/gm	793	769
Burst index(k Pa m^2/g)	3.15	3.40
Tensile index (N m/g)	57.91	49.76
Tear index ($mN.m^2/g$)	4.20	3.94
Black liquor properties		
pH	10.89	10.92
Total solids, % (w/w)	9.45	8.98
RAA as Na_2O, gpl	1.86	3.84
Silica, %	2.5	3.2

Table 4 : Result of kraft pulping of rice straw and bagasse mixed furnish

Parameters	**1**	**2**
Rice straw :Bagasse Ratio	50:50	70:30
Alkali charge% (as NaOH)	12	12
Bath ratio	1:5	1:5
Unscreened pulp yield, %	52.95	49.91
Rejects, %	1.6327	0.8876
Screened pulp yield, %	52.54	45.465
Kappa number	14.36	10.16
Pulp brightness, % (ISO)	30.63	33.27
Pulp viscosity, cc/gm	1042.1	918.0
Burst index(k Pa m^2/g)	4.15	3.80
Tensile index (N m/g)	62.91	55.76
Tear index (mN.m^2/g)	5.20	4.80
Black liquor properties		
pH	11.19	11.51
Total solids, % (w/w)	11.5	10.88
RAA as Na_2O, gpl	1.86	3.844
Silica, %	2.4	3.8

Table 5 : Result of mixed soda pulping of rice straw and wheat straw

Parameters	**1**	**2**	**3**
Rice straw: wheat straw	**100:0**	**50:50**	**70:30**
Alkali charge % (as NaOH)	10	12	12
Bath ratio	1:5	1:5	1:5
Unscreened pulp yield, %	49.0	55.2	55.3
Rejects, %	0.25	2.41	1.33
Screened pulp yield, %	48.8	52.8	53.9
Kappa number	12.1	20.0	13.5
Pulp brightness, % (ISO)	35.4	29.5	33.9
Pulp viscosity, cc/gm	681	855	770
Burst index(k Pa m^2/g)	3.50	3.56	3.73
Tensile index (N m/g)	57.3	66.5	61.6
Tear index (mN.m^2/g)	3.80	4.0	4.3
Black liquor properties			
pH	10.17	10.93	10.83
Total solids, %(w/w)	9.60	10.8	9.95
RAA as Na_2O, gpl	0.28	1.17	0.62
Silica content, %	4.5	4.7	4.6

Table 6 :Results Of Physical Strength Properties of Rice Straw and OCC Blended Pulp

Parameters	**Freeness in (ml CSF)**	**Burst index (k Pa m^2/g)**	**Tensile index (N m/g)**	**Fold Kohler Molin log)**	**Tear index (mN.m^2/g)**
100% rice straw	230	1.98	34.47	17	4.23
100 % OCC	290	1.96	38.86	8	6.02
40:60 (OCC: rice straw	270	1.26	23.11	6	3.98
50:50 (OCC: rice straw	290	1.28	25.69	6	4.37
60:40 ((OCC: rice straw)	290	1.00	22.50	5	4.07
70:30 (OCC: rice straw	375	0.995	20.77	4	4.08
80:20 (OCC: rice straw)	430	0.903	19.40	4	4.06

CONCLUSIONS:

1. Rice straw is undoubtedly a potential raw material for production of paper and paper board.The main drawback associated with use of rice straw as principal source of fiber is the presence of silica.

2. In order to stop the incineration of rice straw an integrated approach is required to make this fiber suitable for various grade of paper and board.

3. The problem can be eradicated through pretreatment of rice starw, mixed pulping and production of semichemical or mechanical grade of paper.

4. The results of two stage solvent pulping of rice straw are very encouraging in terms of unbleached pulp yield gain and reduction of kappa number.

5. Mixed pulping of rice straw along with bagasse and wheat straw is a good substitute of agrobased raw materials alternate, while controlling the silica content in raw material furnish.

6. A very good alternate option of utilization of rice starw for value added product is production of semi chemical/ mechanical grade pulp and itsutilization for manufacturing paper and paper board. The Indian recycled fiber either OCC or ONP can be blended for production of various packaging grade paper and board.

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