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# Test liner paper and folding carton from some lignocellulosic materials

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**Abstract:** *Importance of high yield pulps in paper industry can not be over emphasized. Test linear paper and folding carton can be produced from lignocellulosic materials as rice straw and bagasse using chemical and semichemical process. Semichemical high pulp yield from rice straw and bagasse (63.1% and 73.6% respectively) were obtained using 6% soda at 170°C for 2 hrs. It was found that the carton puncture 19, ring crush 117, taber test 50 was obtained for carton prepared from the above bagasse pulp, while it was 18, 111, 51 for rice straw carton at the same conditions. For bagasse sheets burst factor 199.81, breaking length 6169.3m and tear factor 183.6 was obtained. While for rice straw it was 125.4, 3851m and 179.6 respectively.*

**Keywords:** *Folding carton, test liner paper, alkaline pulping, semichemical pulp, high yield pulp, paper properties*

## I. Introduction

Paper and paperboard are the most prevalent sources of packaging materials in the world. Global production of paper for wrapping, packaging corrugated boxes and other containers increased 75 percent over just the last 5 years [1,2].

To satisfy increasing pulp demands and to conserve wood resources, there is a great interest in substitution of chemical pulps by high yield mechanical pulps in a wide variety of paper grades. High yield pulps require lower capital cost of the paper mills and have low environmental impact associated with their manufacture, as lower chemicals are used. Additionally, the high yield results in roughly twice the pulp produced per ton of raw material as compared to chemical pulps [3]. High yield pulps offer cost effective opportunities in achieving the desired end use performance in properties similar to bleached hardwood kraft pulp, but with other unique features such as high bulk, large surface areas and high fines content [4, 5].

When preparing high yield pulp, such as coarse board pulp, chemical requirements are about 5-9 % of caustic soda. In this case, a very good quality board pulp suitable for corrugating medium and other rough grades of board or for filter pulp and cylinder board can be produced in yields of 70 -75 % [6].

Agriculture residues play a highly significant role as a raw material for pulp and paper industry in some developing countries where wood supply is limited or costly. Non-wood fibers are suited for the smaller mills required for the limited markets in developing countries. The productive capacity of paper making pulp from fibers other than those of wood has increased dramatically to above 10 % of the total production [7]. Bagasse, a sugarcane residue, is a particularly promising material since the collection was carried out by the sugar industry and the residue is available in a clean condition at the mills. Pulping of bagasse chemically and mechanically has been the subject of investigations for making different varieties of paper [6]. Bagasse semichemical pulp has gained increasing attention in recent years owing to its improved strength properties with high pulp yield [8,9]. The screened yield of the mild soda pulping of bagasse ranged between 69.5 to 72% compared with 50% for kraft bagasse pulp and its strength properties are comparable with other chemical pulping [6]. Rice straw pulping gives an opportunity for using it in industry instead of its combustion which causes air pollutions.

This study aims to prepare a semichemical bagasse and rice straw pulps (SCP). The effect of sodium hydroxide pretreatment on yield, brightness, pulp characteristics and paper properties were investigated.

## II. Materials and Methods

### Raw Materials Used

Rice straw, supplied by Rakta Pulp and Paper Company, and depithed bagasse supplied by Kinna mill for Pulp and Paper Industry, Egypt were used in this study. To prepare the rice straw and bagasse samples crushing and screening using 40/60 mesh screens were used. Apportion above 60-mesh screen was used to make all chemical analysis, according to standard methods. Raw materials were conditioned in polyethylene bags for 48 hours, and then their moisture contents were determined.

The raw materials analyses compared with hard wood and the standard methods of analyses are compiled in Table 1.

**Table 1:** Analyses of used raw materials

| Composition % | Rice straw | Depithed bagasse | Recycled carton | Method |
|---|---|---|---|---|
| Extractives | 4.1 | 2.6 | 2.45 | Tappi T 204 om-88 |
| Ash content | 14.1 | 1.4 | 2.1 | Tappi T 211 om-86 |
| Lignin | 17.8 | 19 | 16.0 | Tappi T 222 om-88 |
| Pentosan | 12.5 | 24.2 | 14.5 | Tappi T 223 om-84 |
| Holocellulose | 71.4 | 80 | --- | Tappi T 9 wd-75 |
| $\alpha$- cellulose | 45 | 47 | 62.95 | Tappi T 203 om-88 |
| B & $\gamma$- cellulose | 13.9 | 9 | ----- | Tappi T 204 om-88 |

**Pulping conditions**

Raw materials were cut into small pieces of about 4 cm and subjected to pulping on a stainless steel vessel at different degrees of temperatures for two hours period with different concentrations of sodium hydroxide at liquor ratio 6:1. The pulp samples were disintegrated according to SCAN-M 2:64, and screened through a Somerville reject analyzer (slit width 0.16 mm) at a constant water flow of 8 l/min.

The resulting pulp suspension was collected and washed with water and the pulp yield was determined. The collected fiber material was then used for analysis and to make paper hand sheets. The properties of different pulps were compared at constant pulp freeness of about 45 CSF (Canadian standard freeness according to SCAN - M 4:65).

**Beating and Disintegration**

200 gram of pulp in small pieces were soaked in water for 24 hours, and then beaten in a vally beater at 2 % consistency. At the end of the beating, the stock was diluted with water then the degree of the Schopper Regular (pulp freeness) was determined.

**Sheet Formation**

The paper sheets were prepared according to the Tappi Standard using the model S.C.A. sheet former (AB Lorentzen and Wettre). In this apparatus a sheet of 165 mm diameter (214 $cm^2$ surface area) was formed. The weight of oven - dry pulp used for every sheet was about 1.22 g for paper sheets and 5.03 for carton samples. After sheet formation, the sheet was pressed for 4 minutes (at 5 Kg /$cm^2$) using a hydraulic press. The dry sheets were then placed 24 h for conditioning at 65% relative humidity and temperature ranging from 18 - 20° C.

**Physical Tests of Paper Sheets**

After conditioning, the hand sheet papers were weighted and then divided into suitable pieces for the physical tests. In accordance with the standard methods of TAPPI, the basis weights, the bursting strength, tensile strength and tear resistance of the sheets were measured. Also, puncture test, ring cruch test and taber test were measured for folding carton samples.

## III. Results and Discussion

**Analysis of Raw Materials**

The compositions of the rice straw and depithed bagasse used in this study compared with recycled carton are shown in Table 1.

**Pulping of Rice Straw and Bagasse**

The aim of this study was to find the optimum pulping conditions to produce semichemical pulp from rice straw and bagasse suitable for test linear paper and folding carton.

**Effect of NaOH concentration**

To evaluate the effect of NaOH concentration on pulping of rice straw and bagasse the other pulping conditions were held constant at liquor ratio 6:1, pulping time 2hrs and temperature 170º C. Alkali concentration were varied from 4 to 8 % for rice straw and from 4 to 12 for bagasse. The total pulp yield, physical and chemical properties of the produced pulps has been investigated and the results are reported in Table 2.

**Table 2:** Effect of NaOH % on test linear paper properties

| Pulp properties | Rice straw | | | Bagasse | | | |
|---|---|---|---|---|---|---|---|
| NaOH % | 4 | 6 | 8 | 4 | 6 | 8 | 12 |
| Yield % | 64.6 | 63.1 | 59.0 | 73.0 | 73.6 | 70.5 | 67.6 |
| Breaking length (m) | 3377 | 3851 | 3266 | 3179 | 6169 | 6276 | 6780 |
| Burst factor | 100.6 | 125.4 | 113 | 77.86 | 199.81 | 212.21 | 230.13 |
| Tear factor | 133.2 | 179.6 | 178.4 | 172.4 | 183.6 | 190 | 203.2 |

Table 2 shows that increasing NaOH concentration from 4 to 12 % decreases the bagasse pulp yield from 73 to 67.6 % due to the increased dissolution of lignin and pentosan and may be some degraded cellulose. For rice straw pulp the yield decreased from 64.6 at 4% soda to 59.0 at 8% soda due to higher delignification at higher alkali concentrations.

**Strength properties of pulp**

Table 2 shows that for bagasse test linear paper burst factor, tear factor and breaking length increased as NaOH concentration increased due to more fibrillation for chemical pulp. These results clarify that 6 % NaOH concentration is the most suitable concentration for acceptable paper properties accomplished with semichemical pulp.

For rice straw test linear paper, Table 2 shows that burst factor, tear factor and breaking length increased to optimum value at 6 % NaOH concentration. Also, the table shows that bagasse pulp provide paper with higher burst and breaking strength than rice straw specially at pulping with higher NaOH % .

**Table 3:** Effect of NaOH % on folding carton properties

| | Recycled carton | Rice straw | | Bagasse | | | |
|---|---|---|---|---|---|---|---|
| NaOH % | -- | 4 | 6 | 4 | 6 | 8 | 12 |
| Yield % | 59.0 | 64.6 | 63.1 | 73.0 | 73.6 | 70.5 | 67.5 |
| Density $g/cm^3$ | 0.64 | 0.44 | 0.52 | 0.27 | 0.58 | 0.62 | 0.69 |
| Puncture | 18 | 17 | 18 | 14 | 19 | 16 | 16 |
| Ring Crush | 95 | 92 | 111 | 35 | 117 | 110 | 43 |
| Taber test | 48 | 47 | 51 | 24 | 50 | 35 | 24 |

Table 3 shows the folding carton properties of bagasse and rice straw pulp compared with that of recycled carton. From the table it is clear that pulping with 6 % NaOH provide folding carton with higher puncture, ring crush and taber test for both rice straw and bagasse. This may be due to higher bulk and higher fines content for pulp at this concentration. In comparison with recycled carton, bagasse and rice straw pulp obtained at 6 % NaOH prove comparable or superior folding carton properties.

**Effect of Pulping Temperature**

In order to produce a suitable pulp for test linear and folding carton the most usually used pulping temperature 160 and 170º C were investigated at liquor ratio 6:1, pulping time 2 hrs and NaOH concentration 4 and 6 % for rice straw and bagasse respectively.

Figure 1 shows an increase in rice straw pulp yield from 54.3 to 64.6% by increasing pulping temperature from 160 to 170º C, this may be due to more fibrillation at higher temperature. For bagasse a decrease on pulp yield was observed from 77.4 to 73.0 % at the same pulping temperatures due to more delignification. Pulp density slightly affected by increasing temperature.

Test linear paper properties are shown in Figures (2, 3 & 4). For rice straw pulp by increasing the pulping temperature from 160 to 170º C, burst factor decreases from 125.4 to 100.6, tear factor increases from 96 to 133.2 and breaking length decreases from 4665 to 3377m. While for bagasse increasing the pulping temperature causes an increase in burst factor from 159.85 to 199.81, tear factor nearly constant at 180 and breaking length slightly increased from 6101 to 6169m.

Figure 5 shows folding carton properties. By increasing pulping temperature puncture increases from 17 to 18 for rice straw and from 14 to 19 for bagasse. Ring crush values increases from 92 to 111 for rice straw and from 85 to 117 for bagasse. Taber test values increases from 47 to 51 for rice straw and from 24 to 50 for bagasse. It could be concluded that semichemical pulp of acceptable properties could be attained at both of pulping temperatures 160 to 170º C.

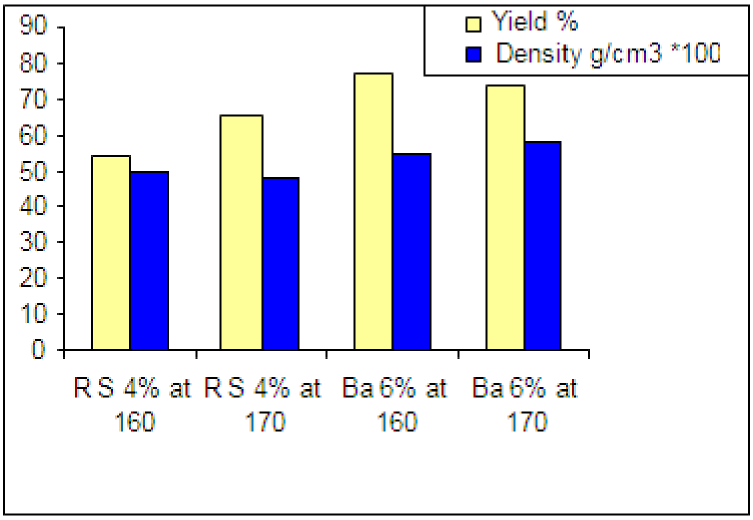



**Fig. (1):** Effect of pulping temperature on the yield and density

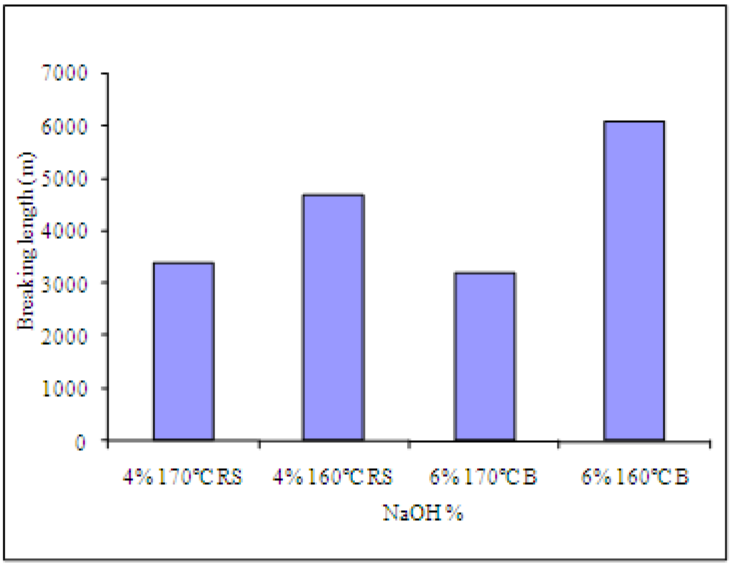



**Fig. (2):** Effect of pulping temperature on breaking length of rice straw and bagasse pulp.

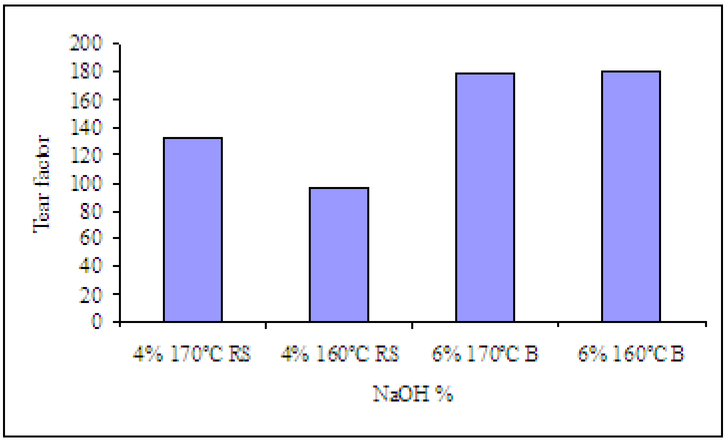
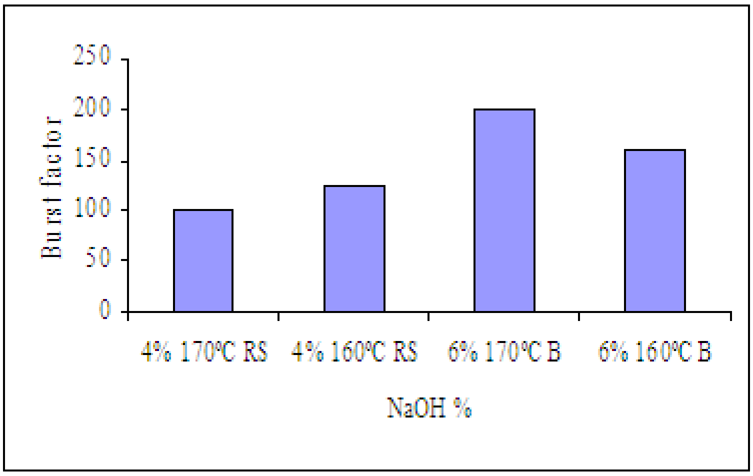
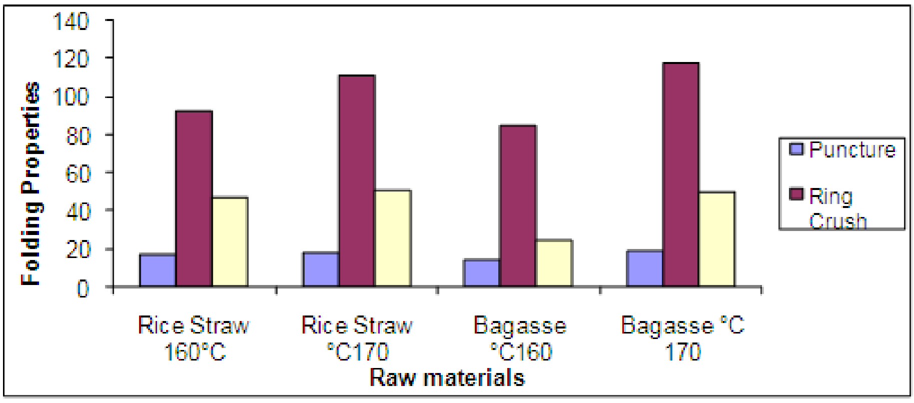



**Fig. (3):** Effect of pulping temperature on tear factor of rice straw and bagasse pulp.




**Fig(4):** Effect of pulping temperature on burst factor of rice straw and bagasse pulp.




**Fig(5):** Effect of pulping temperature on folding carton properties.

**Effect of temperature on 6% soda pulping of bagasse and rice straw**

Semi pilot trails were carried out at Edfu company lab with the aim to prepare a semichemical (SCP) bagasse and rice straw pulps.

**Table 4:** Effect of temperature on 6% soda pulping of bagasse

| Temp. | 110°c | | 125°c | | 145°c | | 160°c 2hr | |
|---|---|---|---|---|---|---|---|---|
| Gramag/m² | 60g | 140g | 60g | 140g | 60g | 140g | 60g | 140g |
| Breaking length (m) | 2824 | 4762.74 | 4873 | 5162.183 | 5837 | 5076.944 | 4772 | 4528.33 |
| Tear Factor | 181.44 | 243.5 | 217.06 | 294.12 | 194.74 | 294.14 | 209.72 | 340.18 |
| Burst Factor | 186.20 | 211.27 | 212.94 | 248.81 | 213.14 | 222.89 | 238.02 | 254.03 |
| Ash % | 0.9 | 0.9 | 1.21 | 1.21 | 2.14 | 2.14 | 1.69 | 1.69 |
| Yield% | 72.06 | | 71.0 | | 70.56 | | 68.4 | |
| Cobb g/m$^2$.min. | 251 | | 252 | | 260 | | 250 | |

**Table 5:** Effect of temperature on 6% soda pulping of Edfu rice straw pulp

| Temp. | 110°c | | 125°c | | 145°c | | 160°c | |
|---|---|---|---|---|---|---|---|---|
| Gramag/m² | 60g | 140g | 60g | 140g | 60g | 140g | 60g | 140g |
| Breaking length (m) | 4104 | 4345 | 5252.6 | 5054.76 | 5666 | 5192.84 | 5157 | 4967 |
| Tear Factor | 161.91 | 186.35 | 99.46 | 121.42 | 114.11 | 155.98 | 104.27 | 142.93 |
| Burst Factor | 172.25 | 200.56 | 236.04 | 258.19 | 286.42 | 274.43 | 275.08 | 280.41 |
| Ash % | 14.26 | 14.26 | 14.4 | 14.4 | 12.46 | 12.46 | 13.66 | 13.66 |
| Yield% | 46.06 | | 30.38 | | 27.0 | | 24.92 | |
| Cobb g/m$^2$.min. | 150 | | 139 | | 142 | | 150 | |

Pulping temperature 110, 125, 145 and 160 ºC were investigated at liquor ratio 6:1, pulping time 2 hrs and soda concentration 6% for bagasse and rice straw.

Tables (4, 5) show a decrease in bagasse pulp yield from 72.1 to 68.4 % by increasing pulping temperature from 110 to 160 ºC, this may be due to more delignification reaction, as well as the degradation of cellulose and pentosan. Also for the rice straw a decrease in the yield occur at the same temperatures and the yield obtained was 46.06 and 24.92 %, respectively due to the same reasons.

From Tables (4, 5) it can be seen that the breaking length increased for bagasse and rice straw by increasing the pulping temperature and the optimum results were obtained at 145 ºC. The best tear factor results were obtained at 125ºC for bagasse pulp, and at 110 ºC for rice straw. The best data for burst factor for bagasse and rice straw pulps were obtained at 160 and 145 ºC, respectively. Increasing pulping temperature have a marginal effect on both ash content and Cobb values for obtained pulps.

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