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Alkaline Peroxide Pulping of Datura stramonium Stalks- A Renewable Source of Fibres for Pulp and Paper In Kashmir Himalaya

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Abstract

Alkaline peroxide pulping of Datura stramoniumstalks harvested from northern Himalayan region of India, Kashmir was investigated for pulp and paper production. The chemical composition including Lignin%, Holocellulose%, Ash%, Alcohol-Benzene solubility%, Hot water solubility%, 1% NaOH solubility was determined as 15.79%, 66.55%, 9.57%, 11.66%, 18.29 and 35.34%. Pre-washed chips were digested at 100°C for 120 minutes with 8% of hydrogen peroxide and 2% of sodium hydroxide.The values of black liquor include pH, Total solids, Chemical oxygen demand and color were7.78, 1.67 %, 25720 ppm and 22564PCU respectively, while as for wash liquor the respective values were 7.48, 0.10%, 12800ppm and 3677PCU.The physical strength properties of standard sheets of 60 gsm of pulp at 8% alkaline peroxide pulping were as tensile strength (44.20 Nm/g), tear index (6.15 mN.m /g), burst index (2.71kPa m^2/g) and double fold number (827). The corresponding values of those standard sheets where no chemical (control) was added were 12.95 Nm/g, 1.9 mN. m^2 /g, 0.09 kPa.m^2 /g and 12 respectively. The results revealed that the Daturastalks at 8% APP pulping issuitablefor paper and paper board making.

I. INTRODUCTION

Among various chemical pulping processes, the more recently developed alkaline peroxide pulping process (APP) have attracted interest and have been the centre point of research and development. Research has been done in the improvement of APP pulp bleaching [1]. APP pulping offers various advantages, including good pulp quality, elimination of the need for a bleach plant, and energy savings [2]. APP pulping has also shown success with non-wood species due to their relatively open and easy-to-disintegrate structure. Such pulping usually generates a lower volume of efferent, thus reducing the environmental impact relative to wood pulping [2]; [3]. The APP pulping potential of various non- wood raw materials including wheat straw [2]; [3]; [4], jute [5]and oil palm empty fruit bunches [6] has been studied. Even though the APP process is desired for its low energy consumption and production of quality pulp, research attempts also focus on refining energy reduction and pulp quality improvement through enzyme treatment of the raw- material [7]; [8]; [3]. The expected shortfall in the supply of wood and the ever-increasing demand for paper has motivated the utilization of low quality wood residues and agricultural-based non-woods such as wheat straw and bagasse. To satisfy the quality wood demand, however, certain non-wood species Daturastramonium has been able to fulfil the needs. Among the fast growth species, datura, in Kashmir valley has attracted recent attention. Daturastramonium is herbal plant with a height of 30 to 80 cm. This plant sometimes grows over one meter in height. On rich soil, it may even reach the

height of 3-4 feet[9]. The stem of Daturastramonium is green or purple, hairless, cylindrical, erect and leafy, smooth, branching repeatedly in a forked manner [10]. The distribution of Daturastramonium is extensive throughout the warm temperate regions of the world. The most common habitats are disturbed sites, wasteland, railway stock yards, river banks, irrigated crops, pastures and agricultural sites. Daturastramonium is probably the most widespread of all the Datura species [11]. Daturastramonium is native to deserts of the North American Southwest, Central and South America, Europe, Asia, and Africa. It is mainly distributed in the Himalaya region from Kashmir to Sikkim up to 2700 m, in the hilly district of central and south

II. MATERIALS AND METHODS

Material

Daturastramonium stalks for paper making was collected fromoutskirts of Srinagar city of Kashmir province of J&K state and was taken to Kumarapa National Handmade Paper Institute laboratory Jaipur (KNHPI) for laboratory analysis. Firstly, the test samples were cleaned of leaves, roots and soil. The raw material was chopped into 2-2.5 inches.

Figure 1.*Daturastramoniun* stalks.

Proximate analysis of Datura stalks

Chopped raw material was oven dried overnight at 103 ± 2ºC and powdered with the help of dust making machineof 0.4 mm slot size by standard TAPPI test method T267-om 85. The required amount of dust was analysed in terms of proximate and chemical analysis.

Chemical analysis

The cooked material obtained after digestion is called pulp and the liquor obtained is called as black liquor. The black liquor after digestion with 8% sodium hydroxide and 2% hydrogen peroxide at bath ratio of 1:10 was analyzed in terms of pH, total solids, chemical oxygen demand and color. Similar procedure was followed to wash liquor but here no chemical was added.

Pulping of Datura stalks

The pulping was carried out in a six bomb digester. The pulping was done with 8% sodium hydroxide along with 2% hydrogen peroxide and without chemical (Datura stalks were fed to digester without any chemical and only water was added). The pulping process was conducted to extract the fibers maintaining bath ratio of 1:10 and for cooking time 3 hours. The pulping conditions are given in Table 1. The cooked material after washing was beaten as per TAPPI method T200 sp-96 up to ~300 ml CSF (Canadian Standard Freeness) The beaten pulp was screened in vibratory screen and subjected to paper making without bleaching for making laboratory sheets of 60 gsm.

Table 1. Pulping conditions of Datura stalks with 8% soda and without chemical

S. No.	Parameters	8% APP pulping	Without any chemical
2	Sodium hydroxide @ 8%	8.0 g	-
	Hydrogen peroxide@2%	5 ml	
3	Temperature, ^{o}C	100	100
4	Time, h	3	3
5	Bath ratio	1:0	1:10

Paper Making

Pulps obtained from Datura stalks (both with 8% APP and without any chemical) were beaten in a laboratory valley beater at 300 mL freeness (Fig. 2). Standard hand sheets of 60 gsm of pulp at 8% APP and without any chemical were made in a standard laboratory hand sheet former using pulp stock of 300 mL of freeness (Fig. 3a). The sheets were then dried in oven and kept in PVC bags for subsequent study.

Figure 2: 8 % APP Pulp

Figure 3: Paper of Datura (8% APP)

Strength propertiesof paper

Laboratory handsheets of 60 GSM were formed from unbleached pulp were conditioned at 27ºC and 65% relative humidity for 24 hours in accordance with Standard TAPPI test method T402 sp-98. After conditioning, the physical strength properties were evaluated as per the standard test

methods (Tensile index by T494 om-01, tear index by T414 om-98, burst index was measured by method T403 om-97, double fold numbers by T423 cm-98 and brightness was calculated according to the ISO 2470-1).

III. RESULTS AND DISCUSSION

Results depicted in the Table 2 showed the proximate analysis of the test speies. The ash content of most of the nonwoodspecies is evidently higher than that of the woody species, conventional hardwood and soft wood species [12]. Percentages of ash content in our study was in the distinctive range for nonwood plants and have significant effect on strength properties.Ash content of the *Daturastramonium* was found less than that of peduncle of banana stem (19.06%) and pseudo stem of banana (13.93%) [13]. Results of Table-2 showed that and *Daturastramonium* specieshad the maximum (66.55%) holocellulose. The high holocellulose content is reflected desirable for the pulp and paper industry as it is interrelated with better strength properties of the paper. Higher the holocellulose content in raw materials, better they are considered suitable for pulp and paper production [14]. Holocellulose content of*Daturastramonium* was larger than that of other nonwood species (straws and grasses) viz, corn stalks (64.80 %) [15]. Lignin is considered to be an undesirable polymer and its removal during pulping and bleaching requires high amounts of energy and chemicals [14]. The lignin content of *Daturastramonium* was lower than *Populus deltoids* (21.80%) [16], Egyptian cotton stalks (22.50%) [17], which supports the statement that the test species have potential for paper making. Alcohol-benzene extractives of nonwood plant wastes consist of waxes, fats, resins, photosterols, non-volatile hydrocarbons, low molecular weight carbohydrates, salts and other water soluble substances [14]. Non wood plant materials have substantially higher alcohol-benzene solubility when compared with bamboo, eucalyptus, coniferous and deciduous wood which are the main fibrous raw materials for papermaking which leads to lower pulp yield and probably higher biological oxygen demand (BOD) load in effluents [18]. The alcohol-benzene solubles in *Daturastramonium* stalks dust are on a higher side. This indicates that dust of *Daturastramonium* stalks contain more of substances like waxes, fats, resins, phytosterols, as well as non- volatile hydrocarbons, low-molecular-weight carbohydrates, salts, and other water- soluble substances [19]. Hot water solubility of our test species was lower than other species like *Crambetataria*(21.82%) [20],*Typhadomingensis* (24.70%)[21], mustard branches (21.0 %) [22]. Higher values of caustic soda solubility may be due to the easy penetration and degradation of the cell wall by alkali [23]. The high NaOH solubility of stalks dust may be due to the presence of low molar mass carbohydrates and other alkali soluble materials [19]. The alkali solubility in test species was in higher range which indicates that there may be decrease in pulping yield because of higher presence of total solids, chemical oxygen demand and biological oxygen demand which contribute higher chemical consumption in pulping and higher load in effluents [24];[25].

Table 4. Proximate analysis of Datura stalksfibers and other non woodfibers

Sample	**Lignin,%**	**Holocellulose,%**	**Ash,%**	**Alcohol-Benzene solubility,%**	**Hot water solubility,%**	**1% NaOH solubility,%**	**References**
Daturastromonium	15.79	66.55	9.57	11.66	18.29	35.34	Our data
Canola	20	77.5	6.6	6.6	5	50.3	[26]
Corn	17.4	64.8	7.5	9.5	14.8	47.1	[27]
Wheat straw	15.3	74.5	4.7	7.8	14	40.6	[28]
Bongkot	17.2	70	0.7	0.9	2.8	17.2	[29]
Sunflower	18.2	74.9	8.2	7	16.5	29.8	[30]

Now a days the paper making area in under severe criticism due its pollution problem.The black liquor obtained from the chemical pulping process of papermaking has been an environmental

concern and disposal problem for the pulp and paper industry due to its high biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, inorganic nutrients along with slowly degradable lignin and its derivatives[31]. As a result, the pulp and paper industry has been challenged in pursuing environmentally safe and cost-effective disposal alternatives. The results of black and wash liquor extracted from stalks after digestion with 8% sodium hydroxide and 2% hydrogen peroxide and wash liquor are presented in Table 3.

The data presented in Table 3 shows that all values of black liquor were more when compared to wash liquor.

Table 3: Black and wash liquor analysis

S. No	Parameters	Black liquor analysis	Wash liquor analysis
1	pH	7.78	7.48
2	Total solids, %	1.67	0.10
3	Chemical oxygen demand, ppm	25720	12800
4	Color, PCU	22564	3677

The characteristic physical strength properties of the Daturastramonium paper are depicted in Table 4. The application of alkaline peroxidepulpings(8%NaOH and 2% hydrogen peroxide)had significant effect on paper properties (tensile, tear, burst and double fold number) of *Daturastramonium*. Chemically obtained paper from APP pulping showed the higher strength properties than controlled paper (without chemical)may be due the better delignification of pulps with higher alkaline nature of chemicals utilized in paper making [32].However, these properties may be improved by treatment with increasing of dosage of chemicals like 10 and 12 per cent[33]; [34].Due to alkaline nature the fibre cell wall became swollen greatly and most of the lignin is removed from the fibres, as a result internal splitting and fibre interior swelling proceed easily [35]which results in higher strength properties at higher dosages with alkaline nature. Similar trend among the pulpings was reported in the studies of[36], [37],[38], [39]),[40] and [41]. The tensile index of test specieswas higher than other nonwood plant fibres viz; vine shoots kraft pulp (6.45 Nm/g) [42] cotton stalks (16.60 Nm/g). The burst index of test specieswas higher than other nonwood plant fibres viz; holm Soda–Aq (0.42 KPa.m^2/g) and Holm kraft (0.53 KPa.m^2/g) [43], *Acacia auriculiformis* soda - AQ (0.80 KPa.m^2/g) [44].However double fold characteristics of *Daturastramonium* unbleached and bleached papers were higher to values to other non wood plant fibres of 10% soda *Saccharumspontaneum*(16) and 12% soda *Saccharumspontaneum*(20) [45],*Musa paradisica* (120) [46]. The data presented in Table 4 also showed that physical strength properties of Datura paper obtained with 8% APP pulping had higher values compared controlled paper where chemicals have not been used

Table 4. Physical strength properties of Daturapaper at 300 mL freeness

S. No	Parameters	Without any chemical	8% APP
1	Tensile index, Nm/g	12.95	37.51
2	Tear index, mN.m^2/g	1.92	5.29
3	Burst index, Kpa.m^2 /g	0.09	1.87
4	Double fold number	12	243

IV. CONCLUSIONS

- High cellulose and low lignin content of test species makesit potential raw materials for the production of pulp and paper.
- APP pulpingsshowed lesser negative impact on environment.

- Best strength properties (tensile strength, tear index, burst index, double fold number and brightness) between the pulpings resulted with APP pulping at 8 per cent dose in *Daturastramonium*than controlled pulping

Thus, it is concluded from the present study that *Daturastramonium* stalks have a promising potential to be used in papermaking using alkaline peroxide pulping ,However the strength properties can be enhanced by increasing dosages of chemical but keeping in view the loss of cellulosic fibres at higher doses. Utilization of this species for paper production shall help in environmental conservation in terms of reducing the stress on forest resources to a greater extent and thus can provide a sustainable renewable option for paper making.

V. RECOMMENDATIONS

On the basis of experiments conducted, it is recommended that *Daturastramonium* L. stalks have a potential and can be used for pulp and paper production for variety of purposes.

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