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Isolation and characterization of lignocellulose fibers from *Datura sramonium* pulps

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ABSTRACT

Present study was envisaged to isolate and characterize lignocellulose fibers from Datura stramonium stalks, alternative raw material for pulp making. Proximate analysis, black liquor analysis and strength properties of test species was evaluated. The results revealed that Ash, Lignin, Hot water solubility, 10% NaOH solubility, Alcohol-benzene solubility and Holocellulose content of Datura stalks were of the order of 9.57, 15.79, 18.29, 35.34, 11.66 and 66.55 per cent respectively. Values of black liquor include pH, Total solids, COD and color were 9.16, 4.30%, 110720 ppm and 48781 PCU. The strength properties of standard sheets of 60 gsm of pulp at 12% sulphite pulping includes tensile strength 60.51 (Nm/g), tear index 5.05 (mN.m /g), burst index 3.27 (KPa m^2/g) and double fold number 1048. The corresponding values where no chemical was added were 12.95 (Nm/g), 1.9 (mN. m^2 /g), 0.09 (KPa. m^2 /g) and 12 respectively. General results revealed that pulp obtained from Datura stramonium stalks has propitious future in pulp and paper fabrication as standby to woody tress. Exploitation of this non-wood weed species for paper production shall help in ecological preservation in terms of plummeting the hassle on forest resources.

Key words: Chemical analysis, Datura stramonium, Proximate analysis, Strength properties, 12% sulphite pulping.

1. INTRODUCTION

Pulp and paper production is one of the high demand sectors in the world of industrial production especially in countries with shortage of wood, such as China and India [1]. Increasingly fast growth of paper consumption has resulted in the utilization of virgin and woody fibres. Not even electronic communication has been able to detract the importance of paper products and their utilization. The paper consumption in the world has increased by 50 percent during the last decade and the quantitative growth of paper production has been accompanied by a demand for new grades and by technological developments in response to ecological challenges [2]. The continued growth in paper consumption will lead to an increased demand for wood; creating additional pressure on the world's diminishing forest resources. Some efforts at the national and international level are ongoing to find suitable substitutes for wood fibres, which are commonly called nonwoods [3]. Nonwood fibre source accounts 6 percent of the total pulp produced globally [4]. FAO 2009 Year Book on Forest Products 2005-2009 revealed that during this period the average nonwood fibre pulp accounted for 11 percent of the total world pulp production. About 88 percent of the nonwood fibre pulp came from Asia where China produced about 70 per cent of the world production [5]. World capacities (except China) for non-wood fibres pulp was reported to be about 1.26 million tonnes in 2010 and expected to increase to 1.30 million tonnes in 2015 [5]. The utilization of nonwood fibres is an ethically sound way to produce pulp and paper compared to the clear-cutting of forests due to their easy availability as agricultural waste, weeds, avoiding shortage of forest resources, good yields, stable production of annual plants and fibres of nonwood species show a wide range of chemical composition characteristics (higher yields of cellulose and lower lignin contents in comparison to those of woods) [6]. Therefore, the utilization of nonwood plant species may help to decipher the fibre shortage anticipated to arise in the future. Nonwood fibres are abundantly available as renewable source and have become one of the important alternative and supplementary sources of fibrous material for pulp and paper making industry even in this electronic world [7].

Datura stramonium 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. The stem of *Datura stramonium* is green or purple, hairless, cylindrical, erect and leafy, smooth, branching repeatedly in a forked manner [8]. Distribution of *Datura stramonium* 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. *Datura stramonium* is probably the most widespread of all the *Datura* species [9]. *Datura stramonium* is native to deserts of the North American Southwest, Central and South America, Europe, Asia, and Africa however it is mainly distributed in the Himalaya region from Kashmir to Sikkim up to 2700 m, in the hilly district of central and south India [8]. To full fill the wood demand, certain non-wood species has been able to satisfy the needs. Among the fast growth species, *Datura stramonium* stalks in Kashmir valley has fascinated recent attention.

2. Materials and Methods

2.1. Materials

Test species for paper making was collected from out skirts of Srinagar city of Kashmir province of J&K state and was taken to Kumarapa National Handmade Paper Institute laboratory Jaipur (KNHPI) for analysis. Initially non wood plant species *Datura stramonium* samples were scrubbed. Leaves, fruits and soil particles were removed from the stalk portion of the plant and the resultant stalks were chopped into 2-2.5 inches.

Figure 1. *Datura stramoniun* stalks.

2.2. Proximate Analysis of *Datura stramoniun* stalks

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

2.3. Black and Wash Liquor Analysis

The cooked material obtained after digestion is called pulp and the liquor obtained is called as black liquor. The black liquor obtained after digestion with 8% sulphite pulping (5% sodium hydroxide and 3% sodium sulphite) 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.

2.4. Washing studies

The washing of the cooked pulp was carried in Buchner funnel to remove the residual black liquor. Distilled water was used for washing until the pH of the liquor was reduced to 8.3 which results in the wash liquor. Both liquors (black and wash) were taken for chemical analysis and washed pulp was taken for beating and refining for paper making.

2.5. Pulping of *Datura stramonium* cooked stalks

The pulping was carried out in a six bomb digester. The pulping was carried at 12% sulphite pulping (7.5% sodium hydroxide and 4.5% sodium sulphite) and without chemical. Cooked material was fed into digester. The pulping process was conducted to extract the fibers maintaining bath ratio of 1:10 and cooking time of 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 of 60 gsm sheets.

Table 1. Pulping conditions of Datura stramonium stalks with 12% sulphite and without chemical

S. No.	Parameters	12% sulphite pulping	Without any chemical
1	Sodium hydroxide @ 5%	7.5 g	-
2	Sodium sulphite @ 3%	4.5 g	-
3	Temperature, ^{o}C	120	120
4	Time, h	3	3
5	Bath ratio	110	1:10

2.6. Formation of Paper Sheet

The cooked pulp obtained from *Datura stramonium* stalks (both with 12% sulphite and without any chemical) was beaten in a laboratory valley beater at 300 mL freeness (Fig. 2). The standard hand sheets of 60 gsm of pulp at 12% sulphite and without any chemical were formed in a standard laboratory hand sheet former using pulp stock of 300 mL of freeness (Fig. 3a & b). The resultant papers were then dried and kept in PVC bags for further analysis.

Figure 2: 12 % sulphite Pulp

Figure 3a. Datura Paper (12% sulphite)

Figure 3b. Datura paper (without chemical)

2.7. Evaluation of Strength Properties Paper

Hand sheets of 60 GSM were made from unbleached pulp was conditioned at 27ºC and 65% relative humidity for 24 hours in accordance with Standard TAPPI test method T402 sp-98. Next to 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 determind according to the ISO 2470-1).

3. Results and Discussion

The results in the Table 2 revealed that the proximate analysis of the test species. it has been found that ash content of the nonwood fibres is significantly greater than that of the woody species, conventional hardwood and soft wood species [10]. The percentage of ash content in the present finding was found in the distinctive range as that of nonwood plants and is having significant effect on strength properties. In the present study ash content of the *Datura stramonium* dust was observed less than that of ash content percentage of rice straw (16.6%), banana stem (19.06%) and pseudo stem of banana (13.93%) [11]. Results obtained in Table-2 revealed that and *Datura stramonium* dust had the good percentage (66.55%) of holocellulose. High holocellulose content is considered as desirable property for the pulp preparation as it is associated with characteristic strength properties of paper. Higher the holocellulose content, superior they are considered suitable for paper making [12]. The holocellulose content of *Datura stramonium* was greater than that of other nonwood species viz, corn stalks (64.80 %) [13]. Lignin is reflected to be an undesirable polymer and its removal during pulping needs great quantities of chemicals [12]. Lignin content of *Datura stramonium* was found lower than *Populus deltoids* (21.80%) [14], cotton stalks (22.50%) [15]. Proximate analysis include alcohol-benzene solubility of nonwood plant wastes consist of waxes, fats, resins, photosterols, non-volatile hydrocarbons, low molecular weight carbohydrates, salts and other water soluble substances [12]. Alcohol-benzene solubles in *Datura stramonium* stalks dust are on a higher side. This indicates that dust of *Datura stramonium* 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 [16]. Hot water solubility of test species was lower than other species like *Crambe tataria* (21.82%) [17], *Typha domingensis* (24.70%) [18], mustard branches (21.0 %) [19]. the high NaOH solubility of stalks dust may be due to the presence of low molar mass carbohydrates and other alkali soluble materials [16]. The sodium hydroxide 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 [20].

Table 2: Proximate analysis of *Datura stramonium* stalks

S. No.	Parameters	Results	Testing methods
1	Ash,%	9.57	T 15wd-80
2	Hot water solubility,%	18.29	T 1 wd-75
3	Alcohol-Benzene solubility,%	11.66	T 6 wd-73
4	1% NaOH solubility,%	35.34	T4 wd -75
5	Lignin,%	15.79	T13 wd-74
6	Holocellulose,%	66.55	T9 wd-75

Liquor acquired from the chemical pulping process of papermaking is called black liquor and has been an environmental concern 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 [21]. As a result, the pulp and paper industry has been challenged in pursuing environmentally safe and cost-effective disposal alternatives. Results of black and wash liquor extracted from *Datura stramonium* stalks after digestion with 12% sulphite and wash liquor are presented in Table 3. The present findings revealed that values of black liquor were more when compared to wash liquor.

Table 3: Chemical (Black and wash liquor) analysis

S. No	Parameters	Black liquor	Wash liquor
1	pH	9.16	8.77
2	Total solids, %	4.30	0.80
3	Chemical oxygen demand, ppm	110720	69291
4	Color, PCU	48781	16583

Characteristic strength properties of the paper achieved from non-wood herbaceous weed are presented in Table 4. Use of chemical pulpings at 12% sulphite significantly affects physical strength properties (tensile, tear, burst and double fold number) of *Datura stramonium* pulp. Results of the present study revealed that paper obtained from sulphite pulp showed the higher strength properties than controlled paper (without chemical) which might be probably due the better delignification of pulps in sulphite pulping by higher alkaline nature of chemicals [22]. It has been found that fibre cell wall became swollen greatly due to the high charge of alkaline pulping doses and most of the lignin is removed from the fibres [23] which results in higher strength properties with alkaline nature. The tensile strength of test species was found higher than other nonwood plant fibres viz; vine shoots kraft pulp (6.45 Nm/g) [24] cotton stalks (16.60 Nm/g). The tear index of paper of the test species was higher than other nonwood plant fibres viz; vine shoots kraft pulp (0.31 $mN.m^2/g$) [25], *Acacia auriculiformis* (3.70 $mN.m^2/g$) [26], wheat straw (3.07 $mN.m^2/g$) [27]. The burst index of test species was higher than other nonwood plant fibres viz; holm Soda–Aq (0.42 $KPa.m^2/g$) and Holm kraft (0.53 $KPa.m^2/g$) [28], *Acacia auriculiformis* soda - AQ (0.80 $KPa.m^2/g$) [29]. However double fold characteristics of *Datura stramonium* papers were higher than other non-wood plant fibres viz. 10% soda *Saccharum spontaneum* (16) and 12% soda *Saccharum spontaneum* (20) [30], *Musa paradisica* (120) [31].

Table 4: Physical strength properties of *Datura stramonium* pulp at 300 mL freeness

S. No	Parameters	Without any chemical	12% sulphite paper
1	Tensile index, Nm/g	12.95	60.51
2	Tear index, $mN.m^2/g$	1.92	5.05
3	Burst index, $Kpa.m^2$ /g	0.09	3.27
4	Double fold number	12	1048

4. Conclusions

- High cellulose and low lignin content of species makes it a potential raw material for the production of pulp and paper.
- Amongst the pulpings studied without chemical pulping was found to have lesser negative impact on environment.
- Best strength properties (tensile strength, tear index, burst index, double fold number and brightness) among the pulpings resulted with sulphite pulping at 8 per cent dose than controlled pulping

From the present study it can be revealed that that *Datura stramonium* stalks have a auspicious future to be used in papermaking. Henceforth the exploitation of these species for paper production shall help in environmental conservation in terms of reducing the stress on forest resources and in turn to combat climate change.

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