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Characterization and Evaluation of Datura Stramonium Stalks as an Alternative Non Wood Raw Material for Paper Production using Soda Pulping

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Abstract **- The study was carried out to evaluate Datura stalks as an alternative raw material for paper production. The proximate analysis of Datura stalks, black and wash liquor analysis and strength properties of paper was characterized. 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, 15.81, 15.9, 57.9, 11.75 and 62.51 per cent respectively. The values of black liquor include pH, Total solids, Chemical oxygen demand and color were 8.66, 4.68%, 81342 ppm and 66203 PCU respectively, while as for wash liquor the respective values were 8.34, 0.95%, 35739 ppm and 21702 PCU. The physical strength properties of standard sheets of 60 gsm of pulp at 8% soda pulping were as tensile strength (37.51 Nm/g), tear index (5.29 mN.m /g), burst index (1.87 kPa m^2/g) and double fold number (243). 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 Datura stalks at 8% soda pulping was well suited for better grades of paper as well as cheap grades of paper and board because of its better physical strength properties and higher cellulose and low ash content.**

1. INTRODUCTION

*Datura stramonium*is commonly known as Jimson weed and belongs to family Solanaceae. *Datura stramonium* L. 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 [1]. The stem of *Datura stramonium* is green or purple, hairless, cylindrical, erect and leafy, smooth, branching repeatedly in a forked manner [2]. The plant has also been used as a narcotic and local anaesthetic drug in many societies [3]. The 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 [4]. *Datura stramonium* plant is an important medicinal plant as it is a well-known source of different phytochemicals [5]. Traditionally, *Datura stramonium* has been used for mystic and religious purposes [6] and as an herbal medicine with narcotic effects or to treat asthma [7]. In the Hindu religion, the seed of *Datura stramonium* is believed to be associated with the God Shiva, which can promote on religious occasions, such as Shivaratri and Swasthani Puja [8]. *Datura stramonium* 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 India [9]

World demand for paper and paperboard is estimated to grow from 300 million tons to over 490 million tons by the year 2020 [10]. The total fibre consumption for paper board production in India will be nearly doubled between 2006 and 2016, growing from 7.4-13.7 million tons in that time frame. Thus, India is wood fibre deficit. This deficiency is forecast to increase at an annual rate of 11.3 percent by 2016 [11]. Forest cover in India is 67.8 million ha (20.6 percent) of the country's area, this translates into a per capita forest area of only 0.8 ha per person, one of the lowest in the world [11].

The utilization of paper and board products increases continuously in developing countries like India due to enhancing population growth, better literacy, development of communication, and industrialization. The current pulp production is not coping with the increase in demand and for this reason the pruning of raw wood materials and continuous deforestation occurs in many areas of the world, which in turn leads to global warming [12].With the future of the wood-based fibre supplies being debated worldwide and depleting forest resources are forcing pulp and paper industry to use various alternate fibrous resources for papermaking such as cereals straw [13], sugarcane bagasse, bamboo [14],esparto grass [15], abaca (manila hemp), sisal and kenaf; [16].Cannabis *s ativa, Ipomea carnea* [17]., *Sesbania aculeate, S. Sesban* [18] and *Hibiscus cannabinus, H. sabdariffa* [19]

2. MATERIALS AND METHODS

2.1. Materials

Plant material for paper making was collected from Srinagar and Kulgam districts of Kashmir province of J&K

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state and was brought to Kumarapa National Handmade Paper Institute laboratory Jaipur (KNHPI) for further analysis. Initially, plant samples were cleaned of leaves, roots and soil. Raw material was chopped into 2-2.5 inches.

Figure 1. Datura stramoniun stalks.

2.2. Proximate Chemical Analysis of Datura stalks

The 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 analyzed 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 after digestion with 8% sodium hydroxide 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

The washing of the digested cooked pulp was conducted 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 stalks

The pulping was carried out in a six bomb digester. The pulping was done with 8% sodium hydroxide 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% soda pulping	Without any chemical
2	Sodium hydroxide @ 8%	8.0 g	-
3	Temperature, °C	120	120
4	Time, h	3	3
5	Bath ratio	110	1:10

2.6. Paper Hand Sheet Making

Pulps obtained from Datura stalks (both with 8% soda 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% soda and without any chemical were made in a standard laboratory hand sheet former using pulp stock of 300 mL of freeness (Fig. 3a & b). The sheets were then dried in oven and kept in PVC bags for subsequent study.

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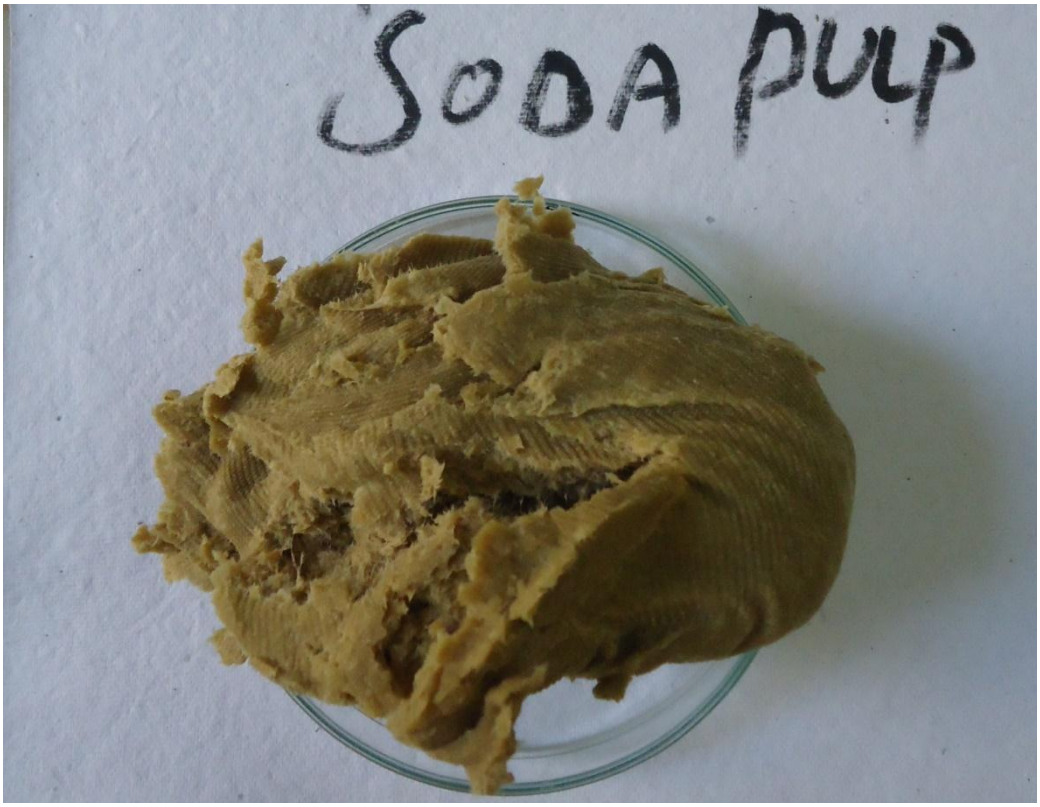

Figure 2. 8 % Soda Pulp

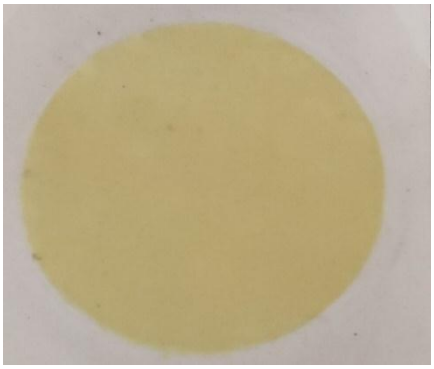

Figure 3a. Paper of Datura (8% soda)

Figure 3b. Paper of Datura (without chemical)

2.7. Paper Strength Properties

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).

3. RESULTS AND DISCUSSION

The results presented in the Table 2 indicate the proximate analysis of the Dautra stalks. The ash content of most of the nonwood fibres is markedly higher than that of the woody species, conventional hardwood and soft wood species [20]. Ash content in our study was in the typical range for nonwood plants and is expected to have significant effect on strength properties. The ash content of the *Datura stramonium* and dust was found less than that of rice straw (16.6%), peduncle of banana stem (19.06%) and pseudo stem of banana (13.93%) [21]. The results presented in Table-2 showed that and *Datura stramonium* dust had the highest (66.55%) holocellulose. High holocellulose content is considered desirable for the pulp and paper industry as it is correlated with better strength properties. Higher the holocellulose content present in raw materials, better they are considered suitable for paper production [22]. The holocellulose content of *Amaranthus hybridus* and *Datura stramonium* wass greater than that of other nonwood species (straws and grasses) viz, corn stalks (64.80 %) [23]. Lignin is considered to be an undesirable polymer and its removal during pulping and bleaching requires high amounts of energy and chemicals [22]. The lignin content of *Amaranthus hybridus* was lower than *Populus deltoids*

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(21.80%) [24], Egyptian cotton stalks (22.50%) [25], 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 [22]. 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 [26]. The 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 [27]. Hot water solubility of our test species was lower than other species like *Crambe tataria* (21.82%) [28], *Typha domingensis* (24.70%) [29], mustard branches (21.0 %) [30]. The higher values of caustic soda solubility may be due to the easy penetration and degradation of the cell wall by alkali [31]. The high NaOH solubility of stalks dust may be due to the presence of low molar mass carbohydrates and other alkali soluble materials [27]. 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 [32];[33].

Table 2. Proximate analysis of Datura 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

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 [34]. 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 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	8.66	8.34
2	Total solids, %	4.68	0.95
3	Chemical oxygen demand, ppm	81342	35739
4	Color, PCU	66203	21702

The strength properties of the paper obtained from Datura stalks are presented in Table 4. Application of chemical pulpings at 8% dose had significant effect on physical strength properties (tensile, tear, burst and double fold number) of *Datura stramonium* pulp. soda paper showed the higher strength properties than controlled paper (without chemical) probably due the better delignification of pulps with higher alkaline nature of chemicals utilized in paper making [35]. However, these properties may be improved by treatment with increasing of dosage of chemicals [36]; [37]. The 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, as a result internal splitting and fibre interior swelling proceed easily [38] which results in higher strength properties at higher dosages with alkaline nature. Similar trend among the pulpings was reported in the studies of [39], [40], [41], [42]), [43] and [44]. The tensile index of test species was higher than other nonwood plant fibres viz; vine shoots kraft pulp (6.45 Nm/g) [45] cotton stalks (16.60 Nm/g). 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) [46], *Acacia auriculiformis* soda - AQ (0.80 KPa.m^2/g) [47]. However double fold characteristics of *Amaranthus hybridus* and *Datura stramonium* unbleached and bleached papers were higher to values to other non wood plant fibres of 10% soda *Saccharum spontaneum* (16) and 12% soda *Saccharum spontaneum* (20) [48],*Musa paradisica* (120) [49].

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Table 4. Physical strength properties of Datura stalks at 300 mL freeness

S. No	Parameters	Without any chemical	8% SODA
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

The data presented in Table 4 showed that physical strength properties of Datura stalks applied with 8% soda pulping had higher values when compared to Datura stalks where no chemical was applied.

4. CONCLUSIONS

- High cellulose and low lignin content of species especially it potential raw materials for the production of pulp and paper.
- Among 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 soda pulping at 12 per cent dose in *Datura stramonium* than controlled pulping

Thus, it is concluded from the present study that *Datura stramonium* stalks have a promising potential to be used in papermaking. Utilization of these species for paper production shall help in environmental conservation in terms of reducing the stress on forest resources .

5. RECOMMENDATIONS:

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

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