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Assessment of Pulp Quality of *Datura stramonium* Stalks as Raw Material for the Manufacture of Ecological Packaging

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ABSTRACT: 12 % soda pulping of non-wood herbaceous species *Datura stramonium* stalks was investigated for pulp and paper production. Chemical characteristics, proximate studies, of liquors and characteristic paper properties of paper of *Datura stramonium* was examined. The outcomes shown that Ash, Lignin, Hot water solubility, 10% NaOH solubility, Alcohol-benzene solubility and Holocellulose content of *Datura stramonium* stalk dust were found of the order of 9.57, 15.79, 18.29, 35.34, 11.66 and 66.55 per cent respectively. Characteristic strength properties of paper sheets obtained by 12% soda pulping of 60 gsm were as tensile strength (43.56 Nm/g), tear index (5.51 mN.m /g), burst index (2.52 kPa m^2/g) and double fold number (373). Analogous values for papers 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 overall results indicated higher cellulosic pulp at 12% soda condition, low ash and lignin content makes it suitable alternative to woody plants for healthier grades of paper and board products.

Key words: Burst index, *Daura starmonium*, Double fold number, Kashmir valley, Tear index, Tensile strength.

I. INTRODUCTION

A sector of paper industry is one of the high demand sectors in the world of industrial production. It has been seen that total global intake for paper-making increase from 316 million tons in 1999 and 351 million tons in 2005 to about 425 million tons by 2010 [1]. Presently fabrication of non-wood pulp mainly takes place in countries with a shortage of wood, such as China and India [2]. Consumption of non-wood fibers is virtuously comprehensive way of production of pulp and paper compared to the clear-cutting of woody trees or prehistoric forests [3]. Other benefit of herbaceous plants as a fiber source includes their fast annual growth [4]. As the impending of the wood-based fibre supply being questioned worldwide, growing interest is being shown to use several alternate fibrous sources for papermaking. Shortage and diminishing wood resources, collectively with augmented paper demand are the lashing forces to use herbaceous materials such as sugarcane bagasse [5] bamboo, [6], esparto grass [7], sisal and kenaf [8]. Herbaceous fibers are copiously accessible and have turned out to be one of the significant substitute and complementary homes for fibrous material for pulp and paper making in developing countries including China, India, Thailand, and Indonesia [9]. Additional non-woods that had been reflected consists of abaca [10], *leucaena* varieties [11], rice straw [12], various agricultural residues [13], empty fruit bunches [14], *hibiscus* species [15], canola stalks [16], rice stem fibers [17] and palm fruit fibers[18].

Himalayan province of Jammu and Kashmir is gorgeous in its plant treasure due to inimitable topography and climatic conditions. A number of non-wood wild plants having well developed stem or stalk system are available in this region which may afford a hefty biomass as raw materials for pulp and paper. With this viewpoint, an endeavour has been made to study physiognomies of *Datura stramonium* for suitability of pulp and paper making.

II. MATERIALS AND METHODS

A. Pre-treatment of the Raw Material

Stalksof test specieswas collected from peripheries of the Kashmir valley and was carried to Kumarappa National Handmade Paper Institute Jaipur (KNHPI) for further investigation. All the leaf and root portion was shredded and only the stem portion was used in the present analysis.

The procured stalkswere washed with tap water to eradicate unnecessary dirt, sand, nodes, and other foreign materials. The washed material was air-dried and then chopped into 1-1.5 inches size with the help of chopper and kept in polyethene bags under shady conditions for further experimental work.

B. Chemical Characterization of Datura stramonium stalks

Sliced stalks were withered in oven at 103 ± 2ºC overnight and then oven dried shreds were converted to dust powder by dust machine of 0.4 mm slot size. The proximate analysis carried out included Hot water solubility (T207 om-99), 10% NaOH solubility (T212 om-98), Alcohol-benzene solubility (1:2 v/v) (T204 cm-97), Lignin (T222 om-02), Holocellulose (T249 cm-00), and Ash (T211 om-93). The pH, conductivity, total solids chemical oxygen demand and color, were determined as per standard APHA testing methods.

C. Pulping Studies

Stem or stalk portion was digested in electrically heated rotary digester of 0.02 m^3 capacity having six bombs, each of 1 L capacity. Pulping was carried at dosage of 12 % soda (NaOH) and without chemical (control) at a temperature of 120^o C for 3 hours with raw material to liquor ratio of 1:10.The condition of soda pulping is given as under.

Table 1: Cooking conditions of soda pulping.

S. No.	Parameters	12% soda pulping	Without any chemical
1.	Sodium hydroxide @ 12%	12.0 g	-
2.	Temperature, ^oC	120	120
3.	Time, h	3	3
4.	Bath ratio	1:10	1:10

D. Washing studies

Washing of the beated pulp was carried in Buchner funnel to remove the residual matter in the cooked pulp and results in the formation of wash liquor. The distilled water was used for washing until the pH of the wash liquor was reduced to 8.3.

E. Preparation of Laboratory Handsheets and Evaluation of Paper Properties

The unbleached pulp of at 12 % soda dosage and without chemical was beaten to different beating levels. Laboratory handsheets of 60 g/m^2 were prepared by standard TAPPI testing method (T221 cm-99) and tested for Tear index (T414 om-98), tensile index (T494 om-01), Burst index (T403 om-97), Double fold numbers (T423 cm-98) and Brightness (%).

III. RESULTS AND DISCUSSIONS

A. Proximate Analysis of Datura stamonium stalks

Proximate analysis of the oven dried dust of *Datura stramonium* stalks (% OD basis) was determined out as per TAPPI testing methods and the results are given in the Table 2.

Table 2: Proximate analysis of *Daturastramonium* stalks.

Percentage	*Daturastramonium* stalks	Testing Method
Ash%	9.75	T211 om-93
Lignin%	15.79	T222 om-02
Hot water solubility,%	18.29	T207 om-99
10 NaOH solubility,%	35.55	T212 om-98
Alcohol-benzene solubility,%	11.66	T204 cm-97
Holocellulose,%	66.55	T249 cm-00

Proximate investigation (Table 2) indicated *Datura stamonium* stalks contains considerable amount of holocellulose and lignin (65.55&15.79%) content which is analogous to straws and grasses. The higher concentration of holocellulose content of test species compared to agro residues and woody raw materials makes it suitable for production handmade paper, thus providing an opportunity for the production of pulp and also can blending these fibrous pulps in various proportions with different non wood fibers, depending on the desired end- products. This will help notonly in tackling the issue of rare woody material scarcity but also help in decreasing the budget of the handmade paper. Hollocellulose is the total polysaccharide fraction of wood or straw or total content of carbohydrate materials. High holocellulose, therefore, is considered desirable for pulp and paper industry because it is linked with higher pulp yield and healthier strength properties by Mabilangan and Estiudillo (1996) [19,20]. Greater the holocellulose content present in raw materials for paper production, superior they are considered for paper production.

The lignin content of *Datura stramonium* stalks samples is comparable or more than other non-wood raw materials and was found lower than that woody pulp. The low lignin content than woody species indicates that these fibres require very mild pulping conditions of alkaline sodium hydroxide.The data presented in Table 2 revealed that test speciesstalks showed lignin concentration of the order of 15.79 per cent. Lignin is considered to be detrimental polymer and its elimination during pulping and bleaching necessitates high quantities of energy and chemicals [20]. High lignin content also advocates long cooking cycle. Additional usage of chemicals may degrade lignin and can afford virtuous pulp but at the same time there will be higher pollution of environment by the production of black liquor and more requirements of fuel, electricity and time which in the long run affect the cost economics in the paper industry. Therefore, lesser the lignin content in non-wood herbaceous raw material superior it will be appropriate for paper fabrication. Lignin content of *Datura stramonium* stalks was comparable or even lower than annual plants and hardwoods (17-26%) especially with Eucalyptus (23.3%); it is however, substantially lower than softwoods (25-32%) [21]. The acceptable levels of lignin content in *Datura stramonium* stalks recommends that this material needs milder pulping conditions (lower temperatures and chemical charges) than those of softwoods and hardwoods. The results also revealed that the potential of test species to undergo bleaching more easily and with application of less chemicals [22]. The results showed that the ash content of the *Datura stramonium* stalks (9.75 per cent) was found less than that of rice straw (16.6 per cent) but higher than that of canola (6.6 per cent), wheat straw (4.7 per cent), corn (7.5 per cent), bngkot (0.7 per cent) and almost similar to that of sunflower. The higher content of ash in the raw material does not depict good for the strength properties of paper, hence forth the species should contain lesser concentration of ash.

The examination of the data in Table 2 indicated that the mean alcohol benzene solubility of *Datura stramonium* stalks was of the order of 11.66per cent. The higher alcohol-benzene solubility values indicate the presence of considerable amount of light weight aliphatic and aromatic compounds. These may decrease the pulping yield of the plant wastes and contribute higher chemical consumption in pulping and higher load in pulping effluent [16]. Non wood plant materials have also 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 [21].

A perusal of the data in Table 2 revealed that the hot water solubility was found 18.29 per cent. The plant material used for papermaking contain higher content of soluble compounds in hot water decrease the pulping yield and thus contribute higher chemical consumption in pulping and higher load in pulping effluent [16]. The water solubility estimates are part of extraneous components, such as inorganic compounds, tannins, gums, sugars, and colouring matter present in the wood and hot water estimates, in addition to starches [15].

The results in Table 2 revealed that the 10% sodium hydroxide solubility content was of the order of 35.55 per cent. The high value of caustic soda solubility may also be due to the easy penetration and degradation of the cell wall by alkali as found by Kristova *et al.* (1998). But at the same time the alkali solubility values were lower than the other commonly used non wood plant materials and grasses [16,20].

B. Chemical (Black and wash liquor) analysis

Chemical characterization of the black and wash liquor of pulp *Datura stramonium* stalks was determined out as per APHA standards testing methods and the results are given in the Table 3.

Table 3: Chemical (Black and wash liquor) analysis.

S. No	Parameters	Black liquor	Wash liquor
1.	pH	9.44	8.93
2.	Total solids, %	4.81	2.01
3.	Chemical oxygen demand, ppm	127360	89446
4.	Color, PCU	125042	27673

The data obtained in Table 3 showed that the black liquor and wash liquor of test species exhibited pH of the order 9.44 and 8.93 respectively, however in case of control (without chemicals (C_0) both black and wash liquor was found lower than that of black and wash liquors which was obtained by chemically treated pulpings as in the later no alkaline chemical was used.

The values of pH of black liquor were found higher than that of wash liquors. The results of our study were in accordance with the findings of Kumar *et al*., 2013 [23]. The pH of the black liquor was found to be high when compared to recommended discharged levels as listed in Minimal National Standards, prescribed by the Central Pollution Control Board, New Delhi (PC Department).

The data presented in Table 3 indicated that the black liquor and wash liquor which was extracted after digestion exhibited chemical oxygen demand (COD) in the order of127360 and 89446 ppm respectively. The values of chemical oxygen demand (COD) of black liquor were found higher than that of wash liquors. The overall results revealed that with the increase in concentration of alkaline dosage chemical oxygen demand (COD) was increased. The results of our study were in accordance with the findings of Kumar *et al*., 2013 [24]. These results are in conformity with those of Dafinov *et al.* (2004) [25].

The results in Table-3indicated that the total solids of black liquor and wash liquor obtained after digestion with the application of 12 per cent soda, was4.81 and 2.01per cent for black and wash liquors respectively.

Total solid content was found highest in chemical pulping and lowest in case of control pulping. The overall results showed that the total solids concentration was much higher in the black liquor when compared with recommended discharged levels as listed in Minimal National Standards, prescribed by the Central Pollution Control Board. But at the same time the total solid concentration was much lower when compared with black liquor effluent of conventional paper mill effluents where paper is being made from softwood and hardwood species of trees [26].

The results in Table-3indicated that the Color of black liquor and wash liquor obtained after digestion with the application of 8 per cent soda pulping was of the order of 125042 and 27673 PCU. The overall results showed that the Color concentration of the black liquor of pulp produced was much lower when compared with the colour of black liquor of conventional paper mill effluents [26].

C. Physical strength properties of unbleached paper

Paper properties are considered as the characteristic properties which actually determine the quality of the paper. The strength properties of test species at soda pulping process with chemical dosages of 12% beaten at 300 ml freeness level was evaluated out as per TAPPI standards [27] and the results are given in the Table 4.

Table 4: Strength properties of unbleached and bleached pulp of *Datura stramonium.*

S. No.	Parameters	Without any chemical	12% soda paper
1	Tensile index, Nm/g	3.95	58.05
2	Tear index, $mN.m^2/g$	0.92	5.96
3	Burst index, $Kpa.m^2/g$	0.02	3.16
4	Double fold number	3	305

Application of soda chemical pulping at the dosage of 12 % NaOH had significant effect on tensile strengthof paper of *Datura stramonium.* Among the pulping, highest strength properties tensile strength, tear index, burst index and double fold no. was found in soda pulping than control in pulping

Characteristic strength properties of the paper achieved from non-wood herbaceous weed are presented in Table 4. Results of the present study revealed that paper obtained from soda 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 [28]. 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 [29]which results in higher strength properties with alkaline nature. The tensile strength of test species was found higher than other nonwood plant fibres viz; 8 % soda palmyra palm fruit fibres (9.20Nm/g) Sridach (2010) [18]. The tear index of paper of the test species was higher than other nonwood plant fibres viz; vine shoots kraft pulp ($0.31mN.m^2/g$) (Jimenez *et al*., 2007), wheat straw ($3.07mN.m^2/g$) [30]. 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 $KPa.m^2/g$) [31]. However double fold characteristics of papers were higher than other non-wood plant fibres. viz; *Acacia auriculiformis* soda - AQ (02), *Acacia auriculiformis* soda (01) and *Acacia auriculiformis* kraft (03) Jahan *et al.* (2008) [32].

V. CONCLUSION

-High cellulose and low lignin content of species makes it a potential raw material forthe production of pulp and paper.

-Amongst the pulpings studied without chemical pulping was found to have lessernegative impact on environment.

-Paramount strength properties (tensile strength, tear index, burst index, double foldnumber and brightness) amongst the pulpings resulted with soda pulping at 12 percent dose than controlled pulping.

After the existing study it can be revealed that that Datura stramonium stalks have anauspicious future to be used in ecological packaging. Henceforth the exploitation of thesespecies for eco-friendly paper production shall help in environmental conservation interms of reducing the stress on woody forest resources.

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