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A Comprehensive Study on Proximate Chemical Composition of *Melocanna baccifera* (Muli Bamboo) and it's Suitability for Pulp and Paper Production

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Abstract

Information on the basic properties of *Melocanna baccifera* (Roxb.) Kurz (Muli bamboo), particularly for pulp and papermaking, is very limited. Since many bamboo species remain unutilized, research is needed to determine their properties so that appropriate technologies could be developed to exploit them. One of such properties which affect the suitability of the species as a pulping material is the proximate chemical composition, which was investigated in a study on *Melocanna baccifera* (Muli bamboo), the most common bamboo from North Eastern India.

Fifty mature culms of *M. baccifera were* obtained from Forest of Silchar, Cachar District of Assam, India. Samples taken from the top, middle and basal portions were thoroughly mixed and used in the study. Determination of proximate chemical analysis was based on TAPPI methods.

Keywords: *Melocanna baccifera* (Muli bamboo); Pulp and paper; Proximate chemical composition; Cellulose; Lignin

Introduction

Melocanna baccifera is a sympodial bamboo growing to about 20 m height unlike other sympodial bamboos, the rhizomes are long and so rather than growing as compact clumps, *M. baccifera* produces groves of widely spaced culms, more akin to those of large monopodial bamboos. It is an aggressive colonizer and often forms the dominant vegetation on the tropical and subtropical hill slopes on which it grows. It is naturally distributed in a swathe cutting south to north from southwestern Myanmar through western central and northern Myanmar and the Chittagong hill tracts of the eastern to the northeastern states of India, where it represents between 60 and 95 regional bamboo resources [1].

In northeast of India, there are so large natural forest of *M. baccifera* (Muli bamboo) distributing in Assam, Tripura, Nagaland, Meghalaya, Sikkim, Mizoram and Arunachal Pradesh. *M. Baccifera* is 3-5 mm in thickness of culm wall and 4-8 cm in diameter. Up to now, they are not utilized adequately. Using *M. baccifera* as papermaking material is a good way for increasing bamboo utilization. Local farmer and government are eager to find a way to use *M. Baccifera* (Muli bamboo) as raw material for industry product to benefit the local farmer and economy development.

Information regarding basic properties of *M. baccifera* (Muli bamboo), particularly for pulp and papermaking, is very limited. Since many bamboo species remain unutilized, research is needed to determine their properties so that appropriate technologies could be developed to exploit them. Two of such properties which affect: the suitability of the species as a pulping material are the proximate chemical composition and Fiber morphology, which were investigated in a study on *M. Baccifera,* the most common bamboo from North Eastern states of India.

Therefore, this research aims to study the technology feasibility of *M. Baccifera* (Muli bamboo) being used as raw material of bamboo pulp.

Material and Methods

For the present study mature culms of *M. baccifera* were randomly selected and felled from the Forest of Silchar, Cachar District of Assam, India. Cachar district is located in the southernmost part of Assam. It is bounded on the north by Barail and Jayantia hill ranges, on the south by the State of Mizoram and on the east by the districts of Hailakandi and Karimganj. The district lies between 92°24'E and 93°15'E longitude and 24°22'N and 25°8'N latitude. The total geographical area of the district is 3,786 Sq. Km.

Samples taken from the top, middle and basal portions were thoroughly mixed and used in the study. A procedure has been adopted to classify the bamboo longitudinal location (Figure 1). Starting with the second internode from the bottom position to the 31st internode, every 10th internode section was taken. The whole culm was divided into three equal length internode number sections (bottom, middle and top). The second and third internodes in each section were selected for physical and mechanical properties determination. Determination of the proximate chemical analysis was based on standard TAPPI methods [2] and that of [3].

Investigating the *M. baccifera* proximate chemical composition will offer significant basic data for the bamboo used in papermaking. *M. baccifera* has been studied in the paper and the details have been shown as follows-

Sample preparation for proximate chemical analysis

M. baccifera for proximate chemical analysis was ground to a fine particle size (40-60 mesh) with Wiley mill to permit complete reaction of *M. baccifera* with the reagents used in the analysis. Chemical methods for analysis of *M. baccifera* typically call for utilization of the entire amount of material without further fractionation. The fine material might contain a disproportionate quantity of some of the *M. baccifera* constituents, and its removal could bias the chemical composition as analyzed. The fine particles were stored in an air-tight container for proximate chemical analysis.

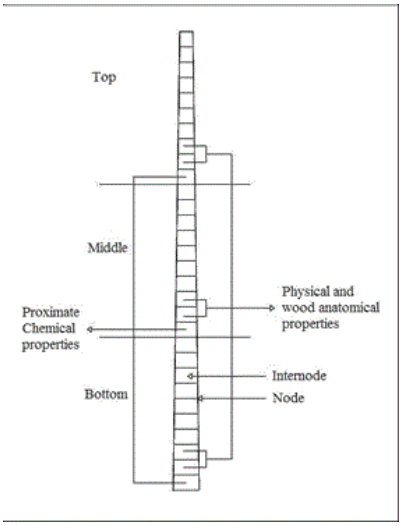

Figure 1: Schematic diagram of sampling technique from bamboo culm.

Experimental Methods

Proximate chemical analysis of the *M. baccifera* samples

Chemical composition of the plant gives an idea of how feasible the plant is as raw material for papermaking. The fibrous constituent is the main important part of the plant. Since plant fibers consist of cell walls, the composition and amount of fibers is reflected in the properties of cell walls [4,5]. Cellulose is the principal component in cell walls and fibers [6-8]. The amount and composition of the cell wall compounds differ among plant species and even among plant parts and they affect the pulping properties of plant material [5]. Some of non woody fiber plants contain more pentosans (over 20%), holocellulose (over 70%) and less lignin (about 15%) as compared with hardwoods [9]. They have also higher hot water solubility, which is apparent from the easy accessibility of cooking liquors. The low lignin content in non woody plants lowers the requirement of chemicals for cooking and bleaching [9]. The exact standards that were followed for chemical analysis are presented in Table 1.

S. N.	Standard Methods	TAPPI No.
1	Cold-water Solubility	T 207 cm-99
2	Hot-water Solubility	T 207 cm-99
3	N/10- NaOH Solubility	T 212 cm-02
4	Alcohol-Benzene Solubility	T 204 cm- 97
5	Holocellulose	Useful method-249-75
6	Klason's Lignin	T 222 cm-02
7	Alpha-cellulose	T 203 cm-99
8	Pentosan	T 223 cm-01
9	Ash Content	T 211 cm-02
10	Moisture content	T 264 cm-88

Table 1: Standard TAPPI Protocols for proximate chemical analysis.

Moisture content of *M. baccifera* dust

2 g air dried dust of *M. baccifera* samples were placed in pre weighed weighing bottles. The weighing bottles with the dust particles were then kept in oven at 105°C for overnight. Then the weighing bottles were removed and placed in the desiccator for cooling it to room temperature before reweighing. The following formula was used to calculate the moisture content (dry-weight) of *M. baccifera* sample.

Dryness % =

W_2 - Stands for weight of weighing bottle + sample.

W_1 - Stands for weight of empty weighing bottle.

Alcohol-benzene solubility of *M. baccifera*

The extraction apparatus consisted of a soxhlet extraction tube which is connected with a reflux condenser on the top and joined at the bottom to a boiling round bottomed flask. 2 g (O.D.) samples from *M. baccifera* were placed into filter paper extraction thimbles. The thimbles were placed in a soxhlet extraction tubes. The boiling flasks contained a 2:1 solution of benzene and distilled alcohol respectively were placed on heating mantles. The extraction was conducted for four hours at the rate of approximately six siphoning per hour. After extraction, the thimbles were removed from soxhlet tubes and dried at 105 ± 2°C for overnight. The materials were removed from thimbles and weighed. The following formula was used to obtain the alcohol-benzene solubility content of *M. baccifera:*

Alcohol-Benzene Solubility %=

W_2 - Stands for O.D. weight of the sample before extraction.

W_1 - Stands for O.D. weight of the sample after extraction.

Hot-water solubility of *M. baccifera*

2 g (O.D.) samples of *M. baccifera* were placed into 500 ml flat bottom flasks with 300 ml of distilled water. Reflux condensers were attached to the flasks and the apparatus were placed on hot plate at 35-40°C for one hour. Samples were then removed from the hot plate and filtered by vacuum suction into G-2 glass crucibles of known weight. The residues were washed with distilled water. The crucibles were oven-dried at 105 ± 2°C for overnight. Crucibles were then cooled in a desiccator and weighed until a constant weight was obtained. The following formula was used to obtain the hot-water solubility of *M. baccifera:*

Hot Water Solubility % =

W_2 - Stands for O.D. weight of sample.

W_1 - Stands for weight of crucible with sample-Weight of empty crucible.

Cold-water solubility of *M. baccifera*

2 g (O.D.) samples of *M. baccifera* were placed into 500 ml flat bottom flasks with 300 ml of distilled water. The flasks were kept at room temperature for 48 hours. Samples were then filtered by vacuum suction into G-2 glass crucibles of known weight. The residues were washed with distilled water. The crucibles were oven-dried at 105 ± 2°C for overnight. Crucibles were then cooled in a desiccator and weighed until a constant weight was obtained. The following formula was used to obtain the cold-water solubility of *M. baccifera:*

Cold Water Solubility % =

W_2 - Stands for O.D. weight of sample.

W_1 - Stands for weight of crucible with sample-Weight of empty crucible

N/10-NaOH solubility of *M. baccifera*

2 g (O.D.) samples of *M. baccifera* were placed into 500 ml flat bottom flasks with 300 ml of N/10 NaOH solution. Reflux condensers were attached to the flasks and the apparatus were placed on hot plate at 35-40°C for one hour. Samples were then removed from the hot plate and filtered by vacuum suction into G-2 glass crucibles of known weight. The residues were washed with distilled water. The crucibles were oven-dried at 105 ± 2°C for overnight. Crucibles were then cooled in a desiccator and weighed until a constant weight was obtained. The following formula was used to obtain the N/10-NaOH solubility of *M. baccifera*:

N/ 10 NaOH Solubility % =

W_2 - Stands for O.D. weight of sample.

W_1- Stands for weight of crucible with sample-Weight of empty crucible

Holocellulose of *M. baccifera*

2.5 g (O. D.) extractive-free samples of *M. baccifera* were placed into 250 ml flasks with small watch glass covers. The samples were then treated with 80 ml of distilled water, 0.5 ml of cold glacial acetic acid, and one gram of $NaClO_2$.The flasks were then placed into a water bath maintained between 70°- 80°C. Every hour for three hours 0.5 ml of cold glacial acetic acid and 1 g of $NaClO_2$ were added and the contents of the flasks were stirred constantly. At the end of three hours, the flasks were cooled until the temperature of the flasks was reduced to 25°C. The contents of the flasks were filtered into G-2 glass crucibles of known weight followed by recycling. The residues were washed with acetone. The crucibles were then oven-dried at 105 ± 2°C, then cooled in a desiccator, and weighed until a constant weight was reached. The following formula was used to determine the holocellulose content in *M. baccifera*

Holocellulose % =

W_2 - Stands for weight of crucible + sample.

W_1 - Stands for weight of empty crucible.

Alpha-cellulose of *M. baccifera*

2 g oven-dried samples of holocellulose were placed in 250 ml beakers with small watch glass covers. The samples were then treated with 10 ml of 17.5% NaOH and thoroughly mixed for 5 minutes. 15 ml of sodium hydroxide solution (17.5%) was further added to the reaction mixture in three equal portions (3-5 ml) at an interval of 5 minutes with constant stirring. After the specimens were allowed to react with the solution for 30 minutes, 33 ml of distilled water was added in each flask and left for another one hour. The contents of the beakers were filtered by aid of vacuum suction into G-2 glass crucibles of known weight. The residues from each flask were washed first with 100 ml of 8.3% NaOH, then with 15 ml of 10% acetic acid and 1000 ml of hot tap water. The crucibles were oven-dried in an oven at 105 ± 2oC, then cooled in a desiccator, and weighed until a constant weight was reached. The following formula was used to obtain α-cellulose in *M. baccifera*.

α-Cellulose % (On the basis of Holocellulose=100

W_2=Weight of the oven-dry α-cellulose residue

W_1=Weight of the original oven-dry holocellulose sample.

Total Alpha Cellulose % =

A- Alpha cellulose on the basis of holocellulose.

B- Percentage of holocellulose in the sample

Klason lignin of *M. baccifera*

1g oven-dried extractive-free dusts were placed in 100 ml beakers. 15 ml of cold sulfuric acid (72%) was added slowly in each beaker while stirring and mixed well. The reaction proceeded for two hours with frequent stirring. When the two hours had expired, the specimens were transferred by washing it with 560 ml of distilled water into 2,000 ml flasks, diluting the concentration of the sulfuric acid to three percent. The flasks were placed on hot plates for four hours. The flasks were then removed from the hot plates and the insoluble materials were allowed to settle. The contents of the flasks were filtered by vacuum suction into G-3 glass crucibles of known weight. The residues were washed with distilled water and then oven-dried at 105 ± 2°C. Crucibles were then cooled in a desiccator and weighed until a constant weight was obtained. The following formula was used to obtain the klason lignin content in *M. baccifera*:

Lignin % =

W_2- Stands for weight of crucible + sample.

W_1- Stands for weight of empty crucible.

Pentosan of *M. baccifera*

3 g (O.D.) samples of *M. baccifera* were placed into 500 ml flat bottom flasks with 300 ml of 13.5% hydrochloric acid. Flasks were connected to pentosan apparatus and boiled the solution. Maintained the acid level in the round bottom flasks by adding 13.5% hydrochloric acid drop by drop continuously through separating funnels. 220 ml of distillates from both samples were collected and made it to 500 ml with distilled water in volumetric flasks. 1 ml from each mixture was diluted with 100 ml distilled water. The absorbances of distillates were noted at 280 nm using spectrophotometer. The following formula was used to obtain the pentosan percent in *M. baccifera*:

Pentosan % =

Ash content of *M. baccifera*

Empty crucibles were ignited in the muffle at 600°C. After ignition crucibles were placed in a desiccator. When cooled to room temperature weighed the crucibles on the analytical balance. 2 g (O.D.) samples of *M. baccifera* were placed in the crucible. Crucibles with contents were placed in the muffle furnace and ignite for 2 hours. The temperature of final ignition was 600°C. Removed the crucibles with its contents to a desiccator, replaced the cover loosely, cooled and weighed accurately. The following formula was used to obtain the ash percent of *M. baccifera*:

Ash % =

W_2 - Stands for weight of crucible + sample.

W_1- Stands for weight of empty crucible

Results and Discussions

The results of the proximate chemical analysis are given in Table 2. *M. Baccifera* appears to be similar to wood in only the holocellulose, alpha-cellulose and lignin contents. In fact these contents are more than the average for Indian hardwoods [8]. The high ash content is expected, since bamboos are known for their very siliceous nature. The large values of the alkali solubles and water (hot and cold) solubles reflect the high contents of hemicelluloses, and sugars and starch present in the bamboo respectively. The large amount of sugars and starch support the fact that bamboos in general have poor natural durability [9]. The high starch content in *M. Baccifera* has been reported [10].

Component	Values %
Cold water solubles	2.8
Hot water solubles	5.8
1% NaOH solubles	19.5
Alcohol-benzene soluble	2.4
Holocellulose	74.1
α-cellulose	47
β-cellulose	19.7
γ-cellulose	7.4
Acid Insoluble Lignin	0.6
Acid Soluble Lignin	25.8
Pentosan	14.42
Ash	1.9

Table 2: Proximate chemical composition of *M. Baccifera.*

Conclusions

Proximate chemical composition and Fiber characteristics of *M. baccifera* have been studied in this paper to assess their suitability for paper production. Based on the analysis results of proximate chemical composition and Fiber characteristics of *M. baccifera* it may say that it has good potential as a pulping material. *M. baccifera* is better in utilization, because of its higher specific gravity, better Fiber length and its distribution, higher wall/lumen ratio. *M. baccifera* is more suitable for the papermaking.

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