International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582–2160, Volume: 4, Issue: 4, July-August 2022

Moringa Oleifera as Fibrous Raw Material for Production of Handmade Paper and Packaging Materials

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Abstract

The aim of this research paper is to find suitability of wood chips of Moringa Oleifera tree for paper and packaging materials as this plant is cultivated in large area of India and many other tropical and sub-tropical areas for its products like drum stick, leaves and seeds. Again, the tree is trimmed every year for better quality of its products. But the tree branches cut are mostly used as fuel material, so this biomass can be better utilized in production of natural cellulosic fibers having good fiber length and used in paper and packaging materials production. The study assessed the fiber characteristics of Moringa oleifera branches for pulp and paper production. Samples are collected from Moringa oleifera trees grown in nearby areas of Sangrur, Punjab. Moringa Oleifera has potential for the Paper Making as it has good fiber length, fiber length to diameter ratio, flexibility and very low percentage of ash. This is supported by relevant analysis of raw material along with several with testing of paper hand sheet samples prepared in paper technology lab. The plant has several medicinal, antibacterial, antioxidant properties, which can be further explored for making specialty paper and packaging materials. This beneficiation of the moringa tree biomass will increase the income of farmers and provide a new potential fibrous raw material for pulp and paper industries which is facing scarcity of good fiber length lignocellulosic raw materials.

Keywords: Moringa Oleifera Tree, Paper Making, Packaging Materials

Introduction

Moringa Oleifera commonly called the 'drumstick tree' and is well known for its multi-purpose attributes, wide adaptability, and ease of cultivation in different climatic conditions. It is a small, fast-growing, drought-deciduous tree or shrub that reaches 12 m in height at maturity and a diameter of 60 cm. The stem is normally straight for a height of 1.5-2.0 m before it begins branching. Today the tree is common to landscapes all over the tropical countries of the world. This tree is cultivated and widely available in south Asian, African and South and Central America countrieslike India and Egypt, Philippines, Thailand, Malaysia, Burma, Pakistan, Singapore, West Indies, Cuba, Jamaica, Nigeria, and Mexico etc.

Moringa Oleifera is a tropical tree with multiple uses and is resistant to drought which makes it suitable for low rain areas of Punjab, Rajasthan, Jharkhand, Madhya Pradesh, Telangana, Maharastra and Andhra Pradesh. The numerous economic uses of Moringa Oleifera together with its easy growth and propagation in most areas have raised growing international interest for its fruit, leaf and flower. Agronomic trails with Moringa Oleifera show that the plant can grow well in hilly areas, in weathered soils of low fertility. India producers 2.2 to 2.4 million tonnes of Moringa drumstick annually in cultivation area of 43600 ha with average productivity of around 50 tonnes per hactor. Andhra Pradesh leads in both area and production (15,665 ha) followed by Karnataka (10,280 ha) and Tamil Nadu (13250 ha) and other states (Sekhar et al., 2017).

Almost every part of the Moringa tree has some beneficial uses. The pods and leaves are very famous as nutritious food. Many research findings have shown moringa as a source of vitamin A, vitamin C, potassium, calcium (Fahey, 2005). It is a fast-growing tree and can be planted using seed or stem cutting. The tree is widely cultivated and naturalised worldwide in the tropics and sub-tropical regions of the world. The other species M. concanensis, a small tree that resembles M. oleifera grows wild in India (Singh et al., 2000).

Moringa oleifera wood was examined for paper making quality and found with the following composition: holocellulose 65.5%, lignin 20.5%, pentosan 11.6%, α-cellulose 40.5% and extractives content of 5.15%, which made it comparable with the eucalyptus and wheat straw, which are widely used ligno-cellulosic raw materials . The bleached pulp had an average fiber length of 1.21 mm, which could be termed better than that of eucalyptus and wheat straw. The mechanical strength properties of the sample paper made of unbleached and bleached pulps, such as tear, tensile and burst indices, were also determined to show their good suitability for pulp and paper production (Sharma et al., 2021).

The search of indigenous sources of good cellulosic natural fibers is urgently required for countries like India having scarcity of forest based softwood and hardwood biomass used in paper and packaging industries. In this direction, alternative raw materials like rice straw, wheat straw and Khar grass have been researched with possible indigenous technologies which will be economical and environment friendly (Jha, 2011; Sinha, 2012; Sinha 2008; Sinha et al., 2012; Sinha 2021; Sinha et al., 2010; Kamboj and Sinha, 2019).

Figure 1: Moringa Oleifera Tree

Material and Methods

Method of Sample Collection and Preparation

Wood samples of Moringa Oleifera were collected from gardens of SLIET. The trees were of age 1 to 5 years with straight stem portions selected and chips were prepared for sampling and pulping process as per TAPPI standards, and then paper making in the form of lab hand sheets.

Table 1: Mean Values of Morphological Properties of Stem Wood Chips of Moringa Oleifera

Debarked Woodchips of the Plant of Age	Fiber Length	Fiber Diameter
1 Year Old	1.16±0.03	17.00±0.01
2 Years Old	1.22±0.02	18.1.±0.01
3 Years Old	1.25±0.04	18.60±0.01
4 Years Old	1.28±0.03	18.65±0.01
5 Years Old	1.29±0.03	19.04±0.01

Influence of Raw Material

Variation of properties like those mentioned will often decide the usefulness of the raw material for various paper and board products**.** The longer the fibers, the stronger the paper since longer fibers allow better interlocking at point of contact between the fibers. The smaller the diameter and thinner wall thickness, the more is flexibility of the fibers. Flexible fibers give astronger paper since they allow better and more point of contact between fibers. The principal factors that determine whether a plant shall or shall not be used in the manufacture of paper are the suitability of fiber (long or short, thin wall or thick, wide lumen or narrow); dependability of supply, cost of collection, transportation, preparation, and tendency to deteriorate in storage.

Processing Steps

- **Raw Material Collection:** The collection, or extraction of raw material for the production of goods and services, especially directly from the natural environment.
- **Chipping:** The materials are chopped into small pieces of 2-3 inches in size.
- **Digestion:** The material is soaked in 2-5% NaOH for an appropriate period. The alkali loosens the ligno-cellulosic bonds, thereby softening the material.
- **Washing:** The softened material is washed with water to remove the black liquor of sodium lignite and unused alkali.
- **Beating:** The washed pulp material is then subjected to beating. Beating is required for getting good quality pulp, depending upon the quality of boards/paper to be produced.
- **Storage:** After beating, the desired pulp is produced which is then stored in storage tanks.
- **Paper Making:** Paper is then making from the pulp of desired quality.
- **Drying:** The wet boards/papers are then allowed to dry.

Results and Discussions

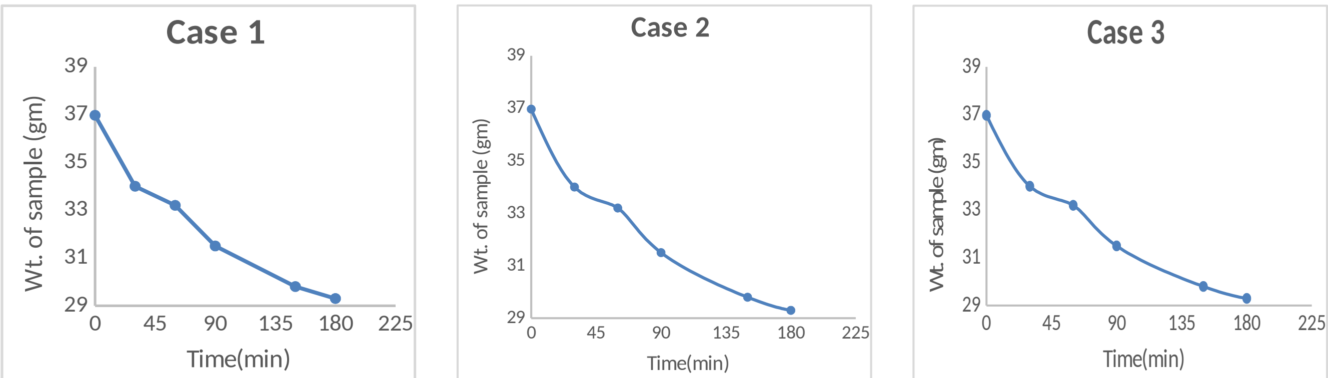
From the results of this work, Moringa Oleifera stem can be used for pulp and paper making. Based on its appreciable fiber lengths and fiber diameter values, Moringa Oleifera is palpable and therefore it can be used in pulp and paper production. 5 year old Moringa Oleifera was best suited for paper making compared to 1 and 3 year old Moringa Oleifera. There was no variation in the means of sapwood and heartwood. That implies that they were both good for pulp and paper making. Along with, the process for the Raw Material, Pulping with Testing of paper is also described above which supports the experimental result of this project. Although, Moringa Oleifera is suitable for the pulp and paper making and this tree is suited for commercial paper making as well.

Raw Material Analysis
Moisture Content
Rate of Oven Drying at Different Condition

In this section, effects on dimensions of the chip by drying to be observed and at last we will see which condition is optimum.

Case No.	Temperature	Chips Dimensions		
		Length	Thickness	Width
1	105±2° C	25.4±0.5 mm	5±0.1 mm	25±0.5 mm
2	105±2° C	27±0.5 mm	5±0.1 mm	25±0.5 mm
3	105° C	25.4±0.5 mm	4±0.1 mm	25±0.5 mm

Figure 2: Drying Rates of Wood Chips with Different Dimensions



After plotting the date of a given condition, it is clear that in the initial duration of drying (unbound moisture content) the slope of Case 2 is greater than Case 1, because the length of Case 1 is lesser than Case 2, so correspondingly area will also be higher in Case 2 because of the rate of heat and mass transfer directly proportional to the active area. Hence more area per unit volume gives more moisture removal.

Now compare the Case 3 with Case 1 both have same per unit volume because length and width are same, but the thickness in Case 3 is lesser than that in Case 1, its effect can be seen during the last stage of drying where bound moisture is removed, thicker chips required more effort to transfer the heat and pass through it however there is no effect of thickness during an early stage of moisture removal (unbound moisture content).

E-ISSN: 2582–2160, Volume: 4, Issue: 4, July-August 2022

So, the desired extent of moisture content is depending on area per unit volume and thickness.

According to the data, mainly collected from secondary sources like research papers, books, articles, and project reports:

The Oven Dry Moisture Content in the raw material (Moringa Oleifera) = Approx. 16-18%.

Figure 3: Samples for Sun Drying and Oven Drying having Different Parameters in Terms of Dimensions

Sample A1

Sample A2

Sample A3

Bulk Density Wood Chips

The Bulk Density in the raw material (Moringa Oleifera) = Approx. 172–187 Kg/m^3

Ash Content

The Ash Content in the raw material (Moringa Oleifera) = Approx. 1.50–2.0%

E-ISSN: 2582–2160, Volume: 4, Issue: 4, July-August 2022

Figure 4: Sample for Ash Content

Experiment Performed

Objective

To perform Batch pulping of given Moringa Oleifera by Kraft-Pulping method.

Apparatus and Reagents

Research laboratory batch digester, aluminium tub, lube oil (for medium heating), electric heater, measuring cylinders, thermometer, safety glass, gloves, beakers, pulp disintegrating machine, washing clothe, sodium hydroxide (NaOH).

Pulping Method

The Digester is a complete pulping unit for producing pulps by cooking Moringa Oleifera cuts like the commercial digester. This is a Batch type digester having a volume of 1.5 L, heated in Al tub having Lube oil as a heating medium, heat provided by an electric heater. Heating is done about 150-160° C for 6-8 hours for cooking purpose of Pulp in Batch Wise Fashion.

According to the quality of raw materials and NaOH added for the pulping time of pulping varies from 6-8 hours for proper pulping. After pulping we wash the chemicals from it by water in a screen, after proper washing we took it into Pulp Disintegrator were fiber are separate and take proper shape. Then again after washing the fiber we prepare Stock for board formation. We put this stock into the proper weight ratio of fiber and water and from the Desired GSM of paperboard. After a few minutes of formation of Board, we put it in Sun or oven for drying purpose.

Procedure

The pulping procedure follows below steps:

1. Collect raw material for pulping (Moringa Oleifera Branches).
2. Cut and dry the raw material for pulp.
3. Prepare the raw material for cooking.
4. Cook the raw material.
5. After cooking, pulp disintegrating will be done.
6. Then the pulp is prepared for washing.

E-ISSN: 2582–2160, Volume: 4, Issue: 4, July-August 2022

Figure 5: Working Process of Pulping

Fiber Separation

The fiber separation stage is the point at which the several pulping technologies diverge. In kraft chemical pulping, the chips are fed into a large pressure cooker (digester), into which is added the appropriate chemicals (white liquor). The chips are then cooked (digested) with steam at specific temperatures long enough to separate the fibers and partially dissolve the lignin and other extractives.

Experiments Performed on Pulping

The hand-made paper producer will manufacture only a few tonnes of paper per year (depending on the number of employees) often for a highly specialized market. In India, where paper making machinery is manufactured indigenously, and hence costs are kept lower, mechanized paper making on a small scale is very common, with plants operating at outputs of 5 tonnes per day and upwards.

The Moisture Content in the pulp	Approx. 18–21%
The ash content in the pulp	Approx. 2.0–4.0%
The Solubility of Pulp in 1% NaOH Solution at 25° C	
A) Sample of Pulp with 20% NaOH Pulping	Approx. 26–28%
B) Sample of Pulp with 18% NaOH Pulping	Approx. 24–26%
Kappa no. of the given Sample of Pulp	
A) 18% NaOH and 6 hours Cooking	Approx. 16–19
B) 20% NaOH and 8 hours Cooking	Approx. 22–23
C) 20% NaOH and 6 hours Cooking	Approx. 20–22
The Length of Pulp Fiber	**Approx. 1.2–1.6 mm**

Based on the analysis of data from different sources, Paper Testing is performed that provides some results to the process. The results of Paper Testing of Paper made from Moringa Oleifera are:

Table 2: Result of Hand-sheet Paper Sample Testing

Grammage of Paper	Approx. 120-300 g/m^2
Opacity of Paper	Approx. 40-49 g/m^2
Tensile Strength of Paper	Approx. 50-100 g/m^2, 40-70 MD and 20-40 CD
Bursting Strength of Paper	Approx. 210-260 kPa
Stiffness / Rigidity of Paper	Approx. 135 g/m^2, 65 MD and 45 CD (Bending Moment Stiffness (mNm)), 1043 MD and 721 CD (Resonance length Stiffness (mNm))
Ash Content of Paper	Approx. 0.3-0.5%
Smoothness / Roughness of Paper	Approx. 45-135 g/m^2, 0.8-2.6 Parker Print Surf micrometers, and 50-300 Bendtsen

Further analysis based on the commercialisation of paper making shows that this process of Paper Making can produce commercial paper with raw material (Moringa Oleifera).

Conclusions

It is concluded that the aim of the project is Paper Making by Moringa Oleifera tree wood chips. It is a tree with higher cellulosic material and having long fibers that make it suitable for paper making. Literature Review / Theory support the selection of raw material for the paper manufacturing. To support the Pulping process various Experiments are performed, these are Moisture Content of Pulp, Ash Content of Pulp, Solubility of Pulp in 1.0% NaOH Solution, Kappa Number of Pulp, and Fiber Length determination of Pulp by Classification. After Pulping Process, Paper Making Process is performed to obtain the paper from pulp and it includes various steps such as Additional Raw Material for the Base Paper, Thereafter, Paper Testing performed including Physical Properties (Grammage), Optical Properties (Opacity), Mechanical Properties (Tensile Strength, Bursting Strength and Stiffness / Rigidity) and Miscellaneous Properties (Ash Content and Smoothness / Roughness). Thereafter, the Commercialization of Paper Making is discussed along with Result and Discussion. This tree is cultivated in large numbers by farmers for drumstick fruits used in vegetable and leaves as protein and mineral source. The tree branches are also trimmed regularly for getting good fruit quality. Again the woody mass do not have high value use and mostly burned so its use as cellulosic fibers for paper and packaging industry will add farmers resource income and provide good fibrous cellulosic raw materials with very good fiber.

References

1. Sandeep G., Anitha T., Vijayalatha K.R., Sadasakthi A. Moringa for nutritional security (Moringa oleifera Lam.). International Journal of Botany Studies, 2019, 4(1), 21-24.
2. Sekhar C., Venkatesan N., Vidhyavathi A., Murugananthi M. Post-Harvest Processing of Moringa and Socio-Economic Appraisal of Moringa Orchards in Tamil Nadu. International Journal of Horticulture, 2017, 7.
3. Fahey J.W. Moringa oleifera: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for Life Journal, 2005, 1(5), 1-15.
4. Singh N.P., Vohra J.N., Hajra P.K., Singh D.K. Flora of India, 2000, 5. Botanical Survey of India, Calcutta.
5. Sharma A., Dhiman G., Lal P.S., Godial R.D., Thapliyal B.P. Characterization of Moringa Oleifera (Drumstick) wood for pulp and paper making. Cellulose Chem. Technol., 2021, 55(3-4), 255-262.
6. Jha P., Sinha A.S.K. Application of rice straw as raw material for production of handmade paper. IPPTA J., 2011, 23(2), 145-148.
7. Sinha A.S.K. Environment friendly removal of silica from wheat straw and Saccharum munja using urea. IPPTA J, 2012, 24(3), 165-169.
8. Sinha A.S.K. Study of effects of process variables of rice straw delignification in catalyzed acetic acid medium at atmospheric pressure. IPPTA J., 2008, 20(2), 107-111.
9. Sinha A.S.K., Singh M., Singh S.P. Acetic acid pulping and ECF bleaching of rice straw and effect of acid concentration on pulp characteristics. IPPTA J., 2012, 24(2), 151-157.
10. Sinha A.S.K. Formic acid pulping process of rice straw for manufacturing of cellulosic fibers with silica. TAPPI J., 2021, 20(8), 489-496.
11. Sinha A.S.K. A novel manufacturing process of paper composite using recycled old newspaper sheets and phenol formaldehyde resin. IPPTA J., 2021, 33(2), 11-16.
12. Sinha A.S.K., Singh M., Singh S.P. Study on use of non-magnetic fraction of pulverised coal fly ash as filler in specialty paper manufacturing. IPPTA J., 2010, 22(2), 117-120.
13. Kamboj R.K., Sinha A.S.K. Lignin separation from black liquor of agro based medium and small scale paper industry for sustainable development. IPPTA J., 2019, 31(2), 120-123.