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Suitability of *Acrocarpus fraxinifolius* as a Pulping Raw Material

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Abstract

The present study emphasized on wood trait indices of *Acrocarpus fraxinifolius* for understanding the suitability of the species for paper and pulp industries. The study was conducted at the College of Forestry, Ponnampet, Karnataka in 2020. The wood core samples were collected from the trees falling under 130 to 150 cm girth class, standing in coffee-based agroforestry systems of Kodagu, Karnataka, India. A total of 12 wood core samples were collected using the Presseler's increment borer at breast height level. For wood fibre analysis the core portion was divided and three, i.e., near to the pith portion, middle and periphery, and made as a composite sample. Core samples were macerated using Jeffreys solution technique at Forest Product and Utilization Laboratory, College of Forestry, UAHS, Shivamogga. Fifty measurements on fibre parameters (Fibre length, Fibre width, Fibre wall thickness, and Fibre Lumen width) were recorded for each sample under a stereomicroscope with an inbuilt Image Analyzer. The mean fibre properties recorded, were used for calculating wood anatomical indices such as the Runkel ratio, Slenderness ratio, Flexibility coefficient, and Rigidity coefficient using standard formulas. The mean Runkel ratio, Slenderness ratio, Flexibility coefficient, and Rigidity coefficient were 0.580, 60.132, 63.290, and 0.184 respectively. The anatomical screening suggests that the species can be used as raw material for paper production, based on the indices. Further research is required to explore the mechanical and chemical properties of commercial exploitation for pulping.

Keywords: Paper, pulp, wood indices, acrocarpus, coffee-based agroforestry system

1. Introduction

Trees and forests contribute substantially to a country's socio-cultural and economic development by providing goods and services to the people. In recent decades, wood has become important raw material for forest-based industries such as sawmills, composite and plywood, pulp, and paper. Paper and pulp industries are the most vital wood-based industries worldwide, consumed in huge quantities. Global paper demand was about 402 mt annum^{-1} in 2011, projected to rise to 521 million tonnes per annum by 2021 (Kulkarni, 2013). India contributes 2.6% of the world's total paper production. The increasing demand for paper and pulp are creating pressure on natural forest. In India, most wood-based industries have been facing a shortage of raw materials, as meeting the demand is a major challenge. As a result of this predicament, industries have become reliant on imported wood products. The cost of importing timber is relatively high and time-consuming. Due to the paucity of raw materials, most paper and pulp companies have closed in recent years. The problem may be progressively handled by supporting local fast-growing tree species for wood-based industries (Kulkarni, 2013, Ghildyal, 1989). *Acrocarpus fraxinifolius* is an indigenous tree regarded as a potential native tree species for making plywood, planks, panel, and construction purpose with other multi-purpose services such as erosion control, fodder, gum, fuelwood, *etc.* (Nath et al., 2012).

Acrocarpus fraxinifolius is a large-sized tree belonging to the family Fabaceae, commonly called Pink Cedar, as the heartwood is pinkish in color. It is locally known as Belanji and Havalige (Kannada), Mandane (Bengali), Nelarai (Tamil), Kurangadi (Malayalam) etc. It is naturally distributed in high rainfall areas in the evergreen forests of Western Ghats, Sikkim, West Bengal, and Assam. Belanji can grow up to 60 m tall with the cylindrical bole free from branches up to ¾ th of its total height. It is cultivated chiefly in Kodagu and Dakshina Kannada as a shade tree in coffee estates (Troup, 1921, Ghildyal, 1989, Ashwath et al., 2020, Das et al., 2022). *Acrocarpus* is best suitable for making plywood, planks, panel and construction, and other multi-purpose services such as fodder, gum, fuelwood, and erosion control. Wood is also a raw material for pulp and paper (Orwa et al., 2009). The leaves have lipoidal content, which exhibits an anti-inflammatory effect (Abouzeid et al., 2011). The n-hexane extract of *A. fraxinifolius* leaves has antihepatotoxic properties (Ghffar et al., 2017) and antioxidant and anti-inflammatory effects, which affect hyperglycemia and hyperlipidemia (Ghffer and Shehata, 2018). Belanji was considered the tree for the future because of its multi-purpose utility and recommended as one of the promising species for Agroforestry.

The quality of paper and pulp is mainly decided by the wood properties such as density, fibre, and vessel dimensions and derived indices such as Runkel ratio, slenderness ratio, flexibility coefficient, rigidity coefficient along with other physicochemical parameters (Rodriguez et al., 2017, Maiti, 2016, Maiti et al., 2016). To pulp and papermakers, a fibre of extended, tubular, cylindrical, and minimal cell derived from plants or plants' parts are necessary with its diameter, which is just 0.1 mm, is minimal, and is thought to be tiny. However, it can range from about 0.5 mm to over 120 mm (Albert et al., 2011, Chaudhari et al., 2016, Ashwath et al., 2021). The length to diameter ratio for popular papermaking fibres ranges from 50 to 200: 1. Always, the fibers increase the quality and quantity of pulp yield, whereas the vessel elements reduce the same (Chaudhari et al., 2017, Jahan et al., 2019). The present effort mainly emphasized on the wood indices of *Acrocarpus fraxinifolius* for knowing the suitability for paper and pulp.

2. Materials and Methods

A total of 12 wood core samples were collected from trees falling under the girth class of 130 to 150 cm, standing in coffee-based agroforestry systems of Kodagu District (N 12° 06' and E 76° 00'), Karnataka, in the month of May 2020. Wood core samples were collected using the Presseler's increment borer at breast height level. For wood fibre analysis the core portion was divided and three, i.e., near to the pith portion, middle and periphery, and made as a composite sample. The wood samples were then macerated using Jefferys solution technique and fibre parameters (Fibre length, Fibre width, Fibre wall thickness, and Fibre Lumen width) were recorded at Forest Product and Utilization Laboratory, College of Forestry, UAHS, Shivamogga (Figure 1) (Ashwath et al., 2021). Fifty measurements on fibre parameters were recorded for each sample under a stereomicroscope with an inbuilt Image Analyzer.

To know the suitability of *Acrocarpus fraxinifolius* for paper making, different wood anatomical indices essential in pulp and papermaking were derived from the data obtained on fibre properties. Anatomical indices *viz.,* Runkel ratio (Runkel, 1949), Slenderness ratio (Varghese et al., 1995), flexibility coefficient, and rigidity coefficient (Tamalang and Wangaard, 1961) were determined using the following formula.

Slenderness ratio= Fibre length/Fibre width---------------------(1)

Runkel ratio=2×Fibre wall thickness/Fibre Lumen Width-------(2)

Flexibility coefficient=Fibre lumen width/Fibre diameter×100.....(3)

Rigidity coefficient=Fibre wall thickness/Fibre diameter---------------------(4)

3. Results and Discussion

The quality of the paper depends on the Runkel ratio, slenderness ratio, flexibility coefficient, and rigidity coefficient (Chaudhari et al., 2017), along with the other physicochemical characteristics. The fibre anatomical ratios were derived from earlier analysis of fibre properties (Ashwath et al., 2021) to assess the suitability of species for pulp and paper. Estimated mean values of different anatomical indices of *Acrocarpus fraxinifolius* are presented in Table 1. The mean Runkel ratio was 0.580, the Slenderness ratio was 60.132, the Flexibility coefficient was 63.290, and the Rigidity coefficient was 0.184. The Runkel ratio of fibres must be less than one (Chaudhari et al., 2017) or in the range of 0.25 to 1.50 (Sarogoro and Emerhi, 2016). The flexibility coefficient decides the strength of the paper, which is directly associated with breaking length and tear resistance. The species having a flexibility coefficient of 50 to 75 gives an excellent paper with high strength properties (Sarogoro and Emerhi, 2016). The slenderness ratio plays a vital role in measuring the tearing strength of the paper. The species with a slenderness ratio of more than 33 is preferable in the quality of paper and pulp production (Varghese et al., 1995, Sarogoro and Emerhi, 2016). Four groups of flexibility ratios have been observed by Bektas et al. (1999) high elastic fibre (FR greater than 75), elastic (FR between 50 to 75), rigid fibre (FR between 30 to 50), and high rigid fibres (FR less than 30). The rigidity coefficient determines the stiffness of the paper. It is acceptable for paper manufacturers if the value is

Table 1: Wood indices deciding the suitability of raw materials for paper and pulp making

Wood Indices	Observed Value*	Desired value#	Reference
Runkel ratio	0.580	0.25 to 1.50	Chaudhari et al., 2017 Sarogoro and Emerhi, 2016
Slenderness ratio	60.132	more than 33	Sarogoro and Emerhi, 2016 Varghese et al., 1995
Flexibility coefficient	63.290	50 to 75	Bektas et al., 1999
Rigidity coefficient	0.184	less than or equal to 0.5	Tamolang and Wangard, 1961

* Values of the present study; # Values of the previous studies for comparison

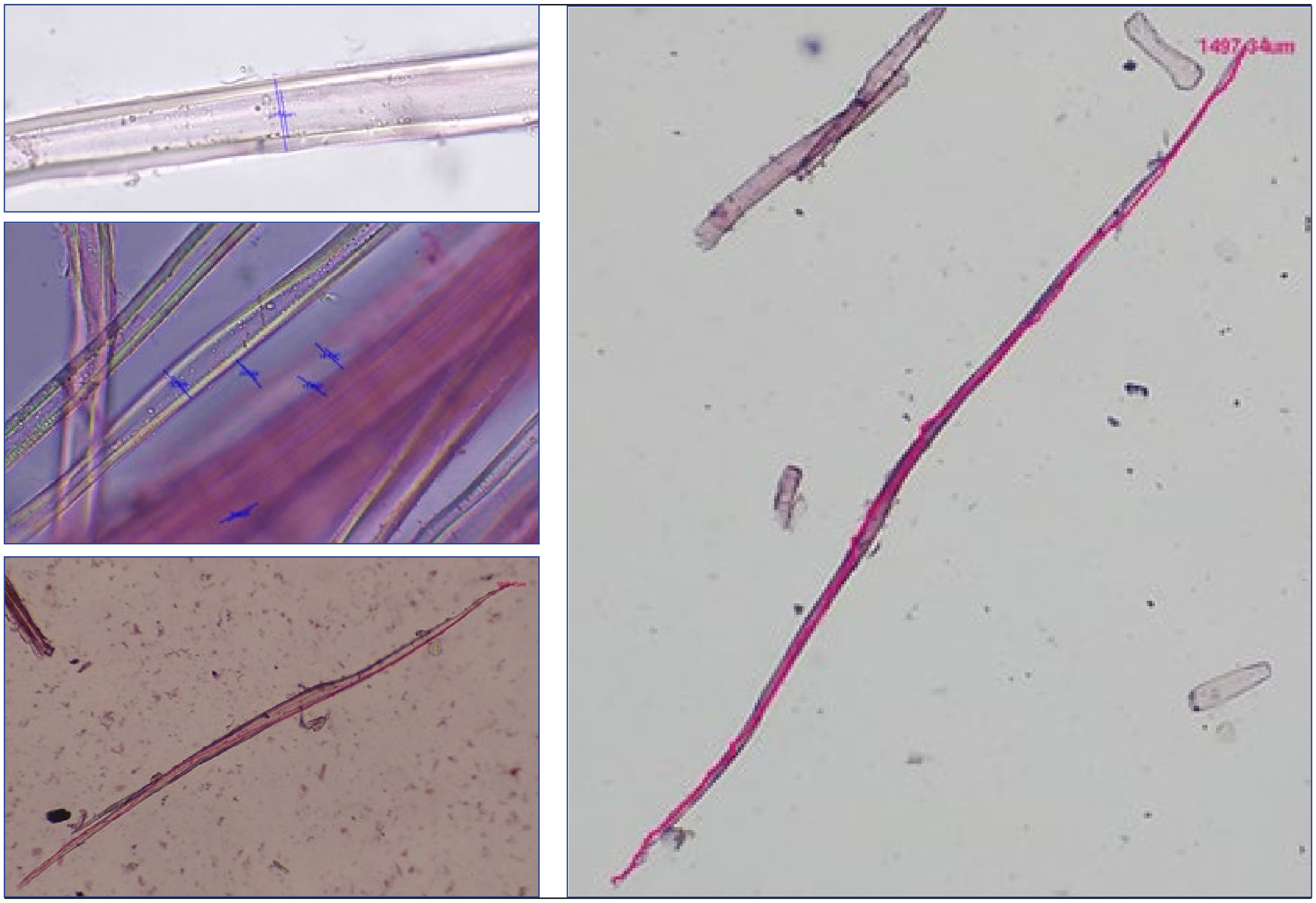

Figure 1: Measuring fibre traits

less than or equal to 0.5. (Tamolang and Wangard, 1961). The anatomical indices meet the parameters described in previous studies, indicating that the species may be appropriate for paper production.

The species is already being used mainly as a raw material in plywood. Pink cedar is suitable for making particleboard (Trianoski et al*.,* 2011), preservative-treated plywood, marine, fire retardant plywood, and plywood for concrete securing grind (Shukla et al., 1993). It is also used as the core material for plywood panels (Pinati et al., 2018). *Acrocarpus* exhibits higher veneer yields with all strong plywood production characters (Parthiban et al., 2019). The species is reported in the production of compensated panels associated with other timber species to improve the quality of plywood (Reis et al., 2019). The resinous material in the wood characterizes Acrocarpus. These factors must be considered, along with pulping ability, cellulose yield, lignin content, and other chemical properties. Since various factors influence pulp and paper yields and quality, more studies must be conducted.

4. Conclusion

Timber having long fibres, slenderness ratio, flexibility coefficient, and low Runkel ratio are considered for high-quality pulp and paper production. The anatomical screening of *A. fraxinifolius* for pulp suggests that the species can be used as raw material for paper production besides its primary use in plywood. Further Industrial level exploration for mechanical parameters and other factors such as lignin, holocellulose, kappa number, and biochemical parameters can be assessed to know the suitability of species for paper making.

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