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RESEARCH AND DEVELOPMENT

# Characterization of the Kenyan *Hibiscus sabdariffa* L. (Roselle) Bast Fibre

**Abstract**
*Hibiscus sabdariffa L. (roselle) is grown in Kenya for its flower and calyx, which are used in the beverage industry. Roselle bast fibre has, however, not been commercially exploited. After harvesting the flowers and calyx the stem together with the bark is used as firewood. This paper reports the characteristics of bast fibres in Hibiscus sabdariffa L. (roselle) grown in Kenya. The bast fibre was characterised by studying its physical and chemical characteristics. The physical characteristics investigated included tensile properties, fineness and surface morphology. An investigation into the type of chemical ingredients present in the fibre was also undertaken. The data obtained in this study indicated that the roselle plant grown in Kenya can produce bast fibres of comparable properties to the kenaf grown in Asian countries.*

**Key words:** *Hibiscus sabdariffa L., roselle, bast fibre, fibre properties, FT-IR, SEM.*

## Introduction

Kenya can grow a variety of natural fibres. One of such fibres that is currently grown commercially and could be of interest for grain packaging is sisal. Kenya is one of the leading producers of sisal in the world [1] and a study of how Kenyan sisal can be utilised for grain storage should be considered. However, since jute bags have been reported to be cheaper than sisal bags [2], this research project endeavoured to study jute-like fibres grown in Kenya but not yet commercially exploited for bast fibres.

One of the jute-like fibres that has been commercialized in Asian countries is kenaf. Kenaf is a type of Hibiscus fibre and its botanical name is *Hibiscus cannabinus L.* Hibiscus plant, which is reported to have originated from Africa and spread to Asia via Egypt [3]. Currently kenaf has been fully commercialised and is one of the commercial bast fibres especially in some Asian countries like China, India, the Philippines and Thailand. Kenaf is found in Kenya and Tanzania, where it grows in the wild and is used as a vegetable [4]. A pilot scheme in Arusha Tanzania set up in 1975 to produce kenaf for fibres failed to pick up due to unfavorable government policies. Similar plans had been initiated in Kenya in the 1960s but failed due to the same problem. *Hibiscus sabdariffa L.* (roselle), another variety of Hibiscus, is common in Asia, South America and Africa. Like kenaf, roselle belongs to the family of Malvaceae. It is an erect annual herb which can grow up to 2 meters in height. Roselle has been grown for its seed, flower, calyx, stem and fibre. In Asia Roselle is grown mostly for its fibres in countries such as Thailand, India and China. In Africa the roselle plant is grown for its flower and calyx [5]. Kenya grows hibiscus (see ***Figure 1***) mainly for hibiscus tea, which is made from the flower and calyces and is exported to Asian countries like Japan. Unfortunately the stem of the Kenyan hibiscus plant is currently of no commercial value despite the fact that it contains bast fibres. Other African countries which include Nigeria, Sudan and Uganda also grow hibiscus for a variety of uses including healthy drinks and medicinal purposes [5 - 7], but little is reported about hibiscus bast fibres from Africa.

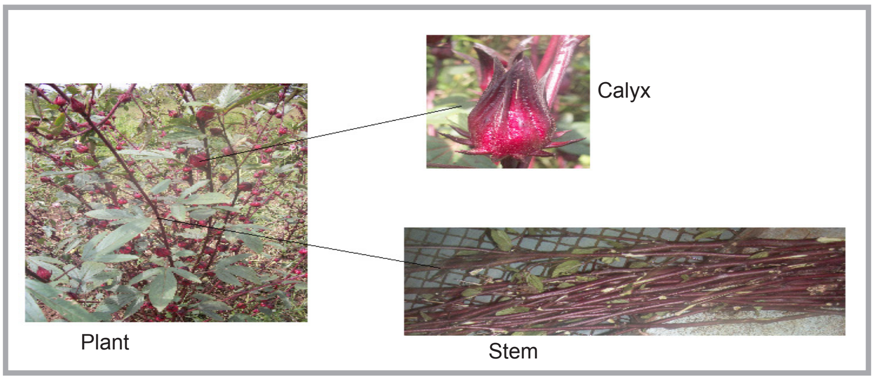


***Figure 1.*** *Hibiscus plant grown in Kenya.*


***Figure 2**. Extraction of Kenyan hibiscus fibres; a) extracting the fibres from retted stem, b) extracted bast fibres, c) drying of the extracted bast fibres.*

The commercialisation of roselle for fibre production in Kenya should not be a problem since the plant originated from the Eastern part of Africa [3]. Research can be done to produce a variety that will be commercially viable to be used for food, pharmaceuticals and industrial purposes (paper and textile industries). It was with this in mind that a project to study the possibility of producing a roselle variety suitable for food and fibre was muted. As an initial step an investigation of the quality of bast fibre produced from the roselle plant currently grown in Kenya was undertaken. Since sisal is commonly used in Kenya to make baskets, a study of the use of hibiscus bast fibre to weave baskets was also investigated.

## Materials and methods

The fibres used in this research work were obtained from the stems of *Hibiscus sabdariffa L24* grown in the Juja area, which is near Nairobi, Kenya. The retting of roselle was done using the steep retting method. The harvested stems (see ***Figure 1***) were laid down in the retting water for 14 days. The fibres were then extracted from the stem and dried under a shade (***Figure 2***). The dried fibres were then characterised, some of which were dyed and used to weave baskets.


***Figure 3**. Use of Kenyan hibiscus fibres to make baskets.*

The fibre characterisation process included the investigation of fibre fineness using the gravimetric method. The measurement of fibre diameter was done using a scanning electron microscope (SEM), while tensile properties were investigated using a single fibre tensile testing machine. A study of the chemical functional groups was done using a Fourier Transform Infrared (FT-IR) - Nicolet 8700 - spectrometer (Japan), and determination of the amount of cellulose, pectin, water soluble matter and hemi-cellulose present in the fibre was also undertaken.

In order to evaluate the surface morphology of the fibre, roselle fibres were investigated using scanning electron microscopy (SEM) - Hitachi TM1000 (Japan). The excitation energy for the general procedure was 15 kV. The fibre samples were sputtered with gold before examination to ensure good conductivity.

X-ray Diffraction (XRD) patterns of the fibres were obtained with a model D/MAX-2550PC X-ray detector diffraction system (Japan) and used to calculate the crystallinity of the fibre. The equipment was set at a voltage of 18 kV, current of 30 mA and scan rate of 2° $min^{-1}$, respectively, from 5 to 60°.

Tensile properties were measured under standard conditions using LLY-06 electric single-fibre tensile apparatus (China), with standard procedures.

## Results and discussions

### Use of Kenyan hibiscus bast fibres to make baskets

The hibiscus bast fibre can be dyed and spun into yarns which can be used to weave baskets, as shown in ***Figure 3***.

### Surface morphology of the Kenyan roselle fibre

The surface morphology of the roselle fibre was viewed using the SEM equipment and the results are given in ***Figure 4.*** The longitudinal view showed some crack-like lines along the length of the fibre, which could be an indication of fibre clusters being held together by gummy material. The cross-sectional view showed the fibres clustered in groups, which is a characteristic fibre assembly for bast fibres, where clusters of fibres are held together by some non-fibrous matter.

### Physical and mechanical characteristics of roselle fibres

The roselle fibres produced, as explained in the experimental section, were investigated for the following properties, whose results are given: length: 500 - 1105 mm, fineness: 4.4 tex. The fibre fineness was comparatively higher compared to roselle fibres grown in Thailand, which has a fineness of 1.9 - 3.6 tex [8, 9].

The fineness of the fibre seems to be high, which could be due to the fact that the fibre is not degummed. During the measurement of the fibre diameter, which gave an average value of 44 µm, it was clear (***Figure 4***) that there is a continuous line along the length of the fibre. This could be due to several fibres being held together by gum, as depicted in the cross-section morphology of the fibres.

The tensile strength of the Kenyan hibiscus fibres measured, as explained in the experimental section, was 20.36 cN/tex and the fibre elongation 2.85%. This is comparable to the results obtained by

***Table 1**. Chemical content of roselle.*

| Ingredients | Percentage |
|---|---|
| Cellulose | 69.38 |
| Lignin | 16.54 |
| Hemi-cellulose | 12.35 |
| Water soluble matter | 1.27 |
| Pectin | 0.32 |
| Wax | 0.14 |

Samad et al 2002 [9] and Eromosele et al [10].

### Chemical characteristics of roselle fibre

The chemical composition of roselle fibre is given in ***Table 1***. The cellulosic content of roselle was higher than that of Kenaf (45 - 63), as reported by Karina et al [11] and Samad et al [9].

### Crystalline structure of roselle fibre

The XRD pattern of roselle fibre given in ***Figure 5*** shows two major peaks at around 16 and 22°, which is close (but not the same) to the Kenaf XRD patterns given by Han et al [12]. Although this pattern is different from the three peak pattern of 14, 16 and 22° for the cellulose 1 crystalline structure, as explained by Wang et al (2010) [13], the 14 and 16° pattern could have overlapped, and therefore the roselle XRD pattern can be adjudged to belong to the cellulose I crystalline structure.

The degree of crystallinity for hibiscus was 64.22%, which is higher than that of jute (53.8%) but lower than that of ramie (72.2 %), another bast fibre, also known as Chinese grass [13]. A higher degree of crystallinity could lead to higher fibre strength.

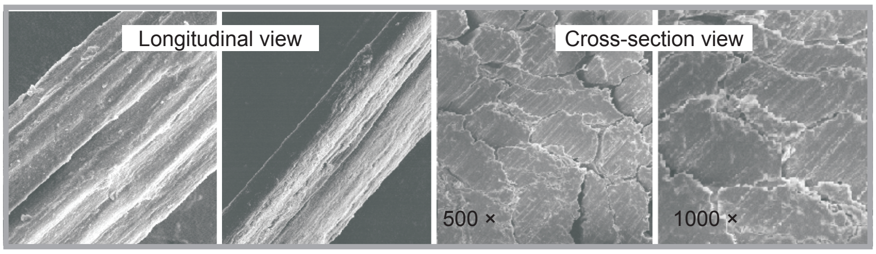


***Figure 4.*** *Surface and X-sectional morphology of Kenyan roselle fibre.*

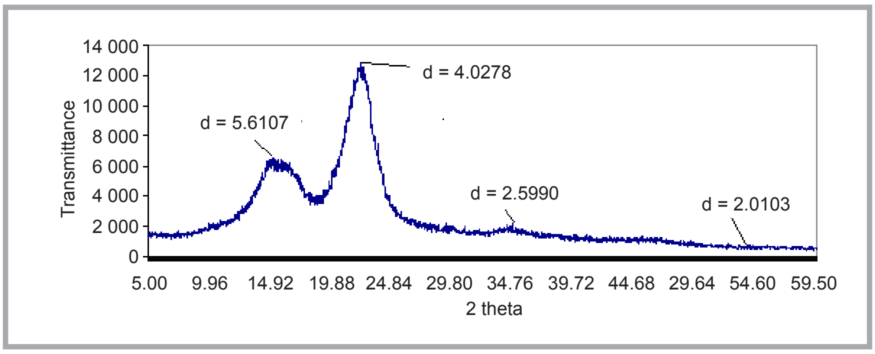


***Figure 5****. XRD graph for Kenyan hibiscus fibre.*

### Chemical groups in roselle fibre (FT-IR)

The Fourier transform infrared (FT-IR) spectra for roselle fibre is given in ***Figure 6***. The peaks at 3355 $cm^{-1}$ and 1035 $cm^{-1}$ could be attributed to the O-H stretching and bending groups, respectively. The vibration peaks at 1700 – 1740 $cm^{-1}$ could be ascribed to C=O stretching, while the vibration peak at 1242 $cm^{-1}$ to C-O stretching vibrations. According to Favaro et al [14], peaks at around 1700 $cm^{-1}$ and 1242 $cm^{-1}$ could be attributed to the C=O and C-O, found in lignin and hemicellulose, respectively, present in natural fibres. Similar results were also reported by Jonoobi et al

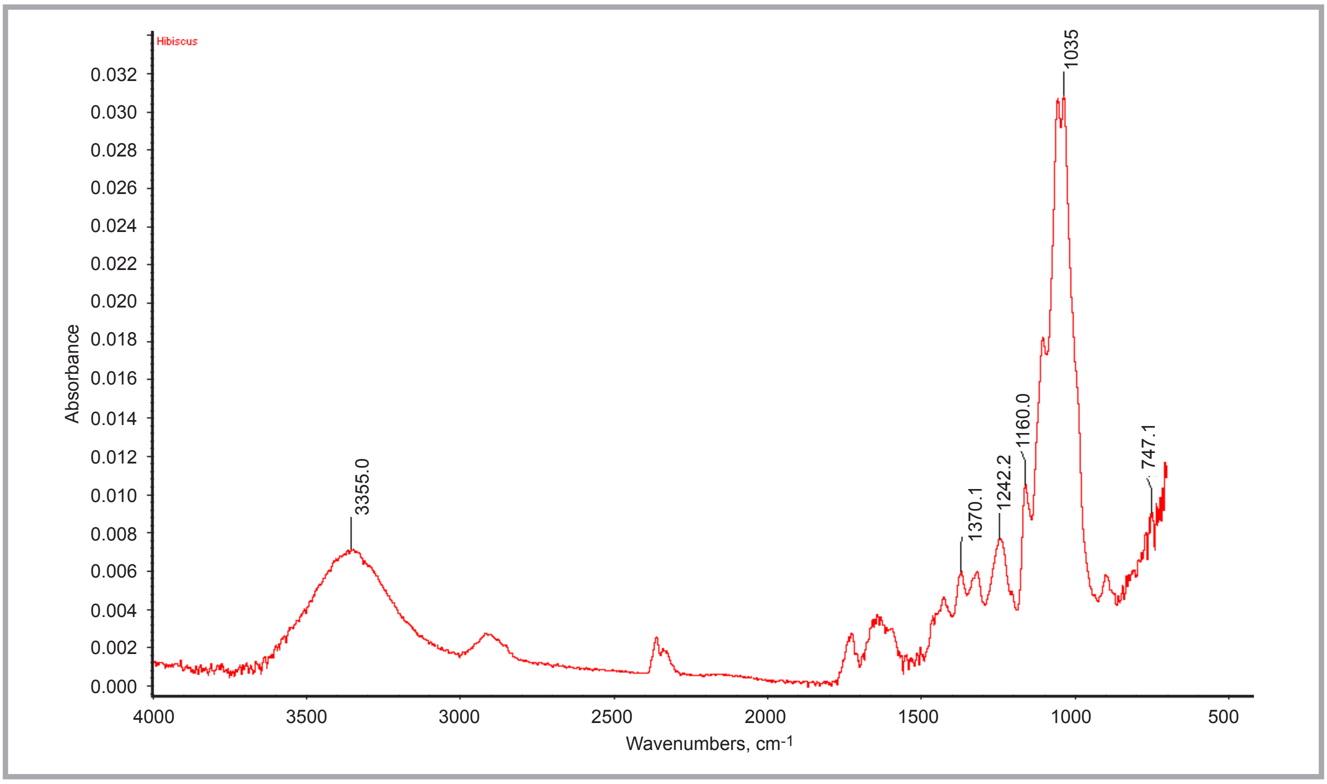


***Figure 6****. The FT-IR results for Kenyan hibiscus fibre.*

[15] and Ibrahim et al [16] when studying kenaf fibres. Other minor peaks at 2900 $cm^{-1}$ and 1370 $cm^{-1}$ could be ascribed to C-H stretching and bending vibrations, respectively.

## Conclusion and recommendations

The characterisation of *Hibiscus sabdariffa L*. (Roselle) fibre grown in Kenya was undertaken. The fibre fineness reported was coarser than expected. The mechanical properties were similar to those of roselle fibre grown in Nigeria. Some of the chemical functional groups were similar to those found in kenaf fibres. The physical properties of roselle suggests that it can be used as a bast fibre, which is adequately supported by the presence of chemical function groups which are also present in kenaf, another bast fibre.

In view of the fact that the fibre recorded a courser than expected fibre fineness we hereby recommend that an investigation into the factors which affect roselle fibre fineness be undertaken. The aforementioned investigation will enable the optimisation of growing conditions so as to ensure fibre of acceptable fineness is obtained.


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