Research Article

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Application of Novel Fibres of *Crotalaria Burhia* for Rope, Rooftop Cover and Mat Production

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ABSTRACT

Crotalaria Burhia (local name Siniya) is a common shrub in arid west of India. These are consumed as fodder by goats and camels in extreme conditions of scarcity of other conventional fodder. Hence due to availability, *Crotalaria Burhia* is traditionally used for manufacturing ropes, and mats. This rural technology is now a rare process and thus becoming obsolete. This article provides a support in reviving this rural traditional technology by expounding about the tensile strength, availability and manufacturing ease as well as sustainability of the products manufactured from this shrub. In this study the above said parameters for *Crotalaria Burhia* are vetted against the other local natural and inorganic synthetic fibres used for similar purposes such as *Leptadenia Pyrotechnica* (local name Khimpda) and *Calotropis Procera* (local name Akara). It is implicated from the study that *Crotalaria Burhia* is better and more viable for rope, rooftop cover and mat production.

Keywords: Bio degradability; *Crotalaria burhia*; *Leptademia pyrotechnica*; Natural fiber; Retting.

1. INTRODUCTION

Crotalaria Burhia, CB, ("Sania" in Marwari Dialect) is small shrub which grows in the Indian Thar to a height of 2 feet (Wanjala *et al.* 1999, Khan *et al*. 2003). It has small yellow flowers. It mainly grows after monsoon rainfall mostly from (July to November). The complete maturity period of this shrub is approximately 4 months (Bhomaram, 2016). It generally grows in the western part of Rajasthan. There are 300 species of CB around the world of which 18 are in India (Wanjala *et al.* 1999). Bhomaram (2016) also asserted that CB has traditional uses as a soil binding agent and fodder for goats during famine (Bhatta *et al.* 2002). The endemic CB is very used as a traditional medication and is used for curing hydrophobia, gout, and swelling (Asolkar *et al.* 1992, Hameed *et al*. 2011, Kataria *et al.* 2011, Khan *et al.* 2003). Anti-microbial properties of CB are also popular in the region (Khanna *et al.* 1980, Naseem *et al.* 2006).

During summer, it provides a cooling effect due to which it is often used as construction material for rooftops in arid regions of Western Rajasthan. The fibers extracted from Siniya are considered quite strong and hence used for making the nettings of the traditional cots (Bhomaram, 2016). Traditionally three plants namely *Crotalaria Burhia* , Leptadenia Pyrotechnica, LP, (local name "Khimpda") and Calotropis Procera, CP, (local name "Akara") are used to extract natural fibers (Bhomaram, 2016). But this technology is now almost obsolete with the advent of plastics.

Rijswijk *et al.* 2001 discussed about three different categories of natural environment friendly fiber namely leaf fiber, fruit fiber and bast fiber. Leaf fibers (pineapple leaf) are obtained from leaves (Sharma, 1982). Fruit fibers (Coir) are generally outer cover of fruits and consist of numerous thin fibers (Rijswijk *et al.* 2003). Bast fibers include fibers extracted both from the inner and outer stem of plants (Celino *et al.* 2014). In this article bast fibers extracted from the three traditional plants are used to manufacture ropes.

The main objective of the study is to understand traditional methods of extraction of fibers from CB plants and to assess its comparative variability with Akara and Khimpda. Tensile, stiffness behavior and Young's Modulus of the ropes manufactured from these fibers is studied to assess its viability as a natural geotextile material such as coir. Hence the selection of natural fibers had been performed keeping in mind the soil binding properties, traditional use and strength.

2. MATERIALS & MANUFACTURING PROCESS

2.1 Raw Plant Materials

CB and LP are shrubs whereas CP is a small tree (Bhomaram, 2016). Elliptic-oblong leaves attached to the stem without any distinct projecting support are a character of CB. It has high regeneration potential and can be harvested every year.

Leptadenia Pyrotechnica is a leafless shrub. It is drought-resistant plant with excellent soil binding properties. Its height varies between 0.6 m-2.5 m. It has erect branches has a structure similar to *Crotalaria Burhia* but has high height and bit dark green in color. (EOL, 2008).

Calotropis Procera is a flat elliptic leaf flowering plant having rough whitish green stem and produces toxic sap when cut. Its height varies from 1-3 meter and leaves are 10-13 cm wide and 17-19 cm long (EOL, 2015).

2.2 Fiber Extraction Process

In the first stage, green shrub is extracted from ground by one of the following methods. First one involved holding the shrub from the bottom and twisting it till it comes out of the ground. In the second method the plant is cut using a sickle and left to grow again and can be used. Once cut, CB samples are dried in open area for about 15 days. It is also noted that after removing the moisture it can be kept for many days without getting rotten. After drying, retting of fiber is done. Its aim is to burst the bark of the stem and increase moisture penetration into the inner portion of the stem (Bhat and Nambudiri, 1971; Prabhu 1957). Siniya or CB retting is a bit different from that of jute and coir due to the paucity of water in arid regions (Bhomaram 2016; Meenatchisunderam, 1980; Varma *et al.* 1984). Traditionally retting the process starts in the late evening by soaking a bunch of CB shrubs in water for about 15 minutes and is then buried under wet desert soil for 5-8 hours (Bhomaram, 2016).

After retting, it is taken out and cleared of the soil by simple manual thrashing on a hard surface. Then cleaned specimen of the shrub is beaten on a hard surface by special round mallet or Mogri . This timed beating (15-20 min) opens the stem and increases its flexibility.

2.3 Fiber Rope Making Process

The processed or extracted CB is now washed thoroughly with water and kept in moist soil for 20 to 30 mins. Now, the CB is ready to be hand woven into ropes.

Subsequently, the rope specimen is tied at one end twisting of another end is done manually. This twisting is done by rotating another free end with tradition arch shaped wooden equipment or "Batiya" which works on the principle of rotation of eccentric loading.

This rotated CB rope specimen is dried for few hours to reduce moisture content. Finally processed Siniya or CB rope is rubbed around wooden or iron pole for 10- 15 minutes for smoothening of final product. This final product is used as a multipurpose rope. The Khimpda rope manufacturing process is almost similar but the variations are illustrated in Table 1 below.

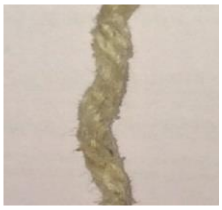
Traditionally, Aakra fibre extraction process takes about 1 year. Aakra branches are cut down and stored in nascent stage for about 1 year. After 1 year, outer bark loosens a bit and it is removed manually into long strips. Afterward these strips are woven into loose long structures. This fiber is then beaten to loosen up the hard / dark bark material from internal fiber. After loosening of undesired material, fiber is cleaned up. Finally, fiber is tightened up by rotating with Batiya from one of its ends to get a strong rope which is soft in nature (just like cotton).

Table 1. Processing parameter comparison for natural fiber rope manufacture.

Plant	Drying Time (Hours)	Soaking Time of Retting (Min)	Time for covering with soil (Hours)	Total duration for Fiber manufacture (Days)
Siniya	10 - 15	15 - 20	5 - 8	11 - 16
Khimpda	10 - 15	15 - 20	5 – 8	11 - 16
Akara	8760	-	-	366

Siniya sample

Khimpda sample



Akara sample

Fig. 1: Sample images of different 3 strand fibers produced.

3. TENSILE STRENGHT MEASUREMENT & METHODOLOGY

The tests were performed according to IS 2307:2010 for the tensile properties of ropes. In this test, dry samples of Siniya, Khimpda and Akara were tested. The prepared ropes are shown in Fig 2.

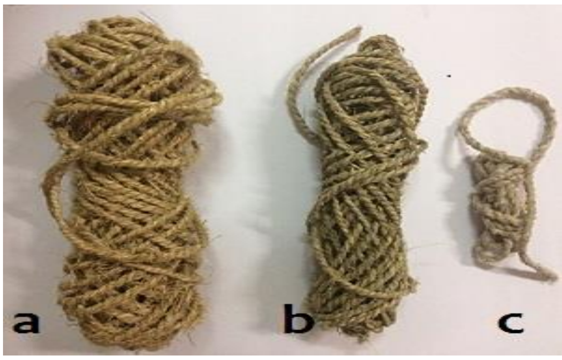


Fig. 2: Ropes of Siniya (a), Khimpda (b) and Akara (c).

The strength of these may depend on the content of hemi-cellulose and lingo-cellulose within individual fibers and also on the spiral angle which the micro-fibril bands make with the fiber axis (Li *et al*. 2000). The average diameter of samples was taken as 6.205mm. The central limit theorem was satisfied and 25 data sets for each parameter of the distinct fibers were measured.

The gauge length of the specimens was 100mm and ends of the specimens were clamped between the modified jaws. The samples were tested at low extension rate of 10mm/min. The tensile test was done on Universal Testing Machine (UTM-EZ50, Lloyd Instruments, UK) with maximum load capacity 50KN).

4. RESULTS & DISCUSSIONS

The Siniya ropes were found to have comparatively higher strength than the other two natural fiber tested here. The Siniya rope tensile strength values are close to Teflon which has an average strength of 29.5MPa (CES, 2016). All the natural fibers tested fared well against other synthetic fibers such as Butyl Rubber (7MPa) and Neoprene (9.3MPa). Thus, natural fibers always are efficient for work during high tension requirements (CES, 2016).

From Fig. 3&4, comparative stiffness of Akara was better than Siniya and Khimpde. This is also supported by the Young's Modulus values of the material as illustrated in Fig. 5. It is also found that due to this property Akara fibers were only used for mostly winding operation where stiffness requirement in high. For example, one of its uses is in production of netting of sleeping cots (Bhomaram, 2016).

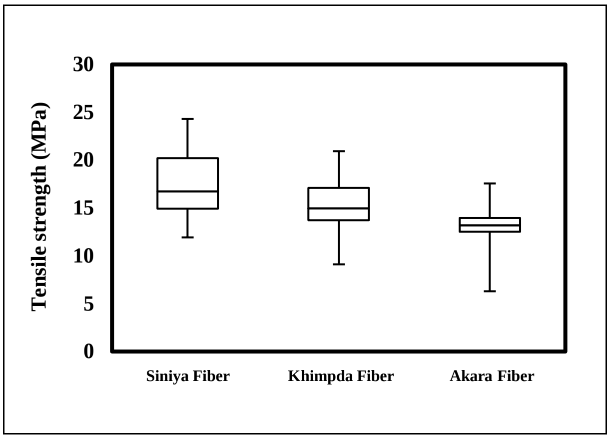


Fig. 3: Box plot illustrating variability of tensile strength of the three distinct fibers.

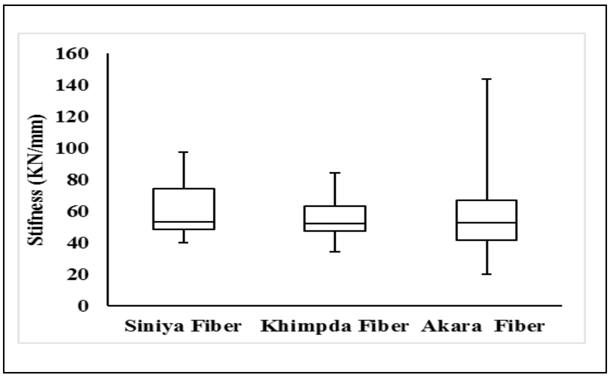


Fig. 4: Stiffness variation in the three distinct natural fibers.

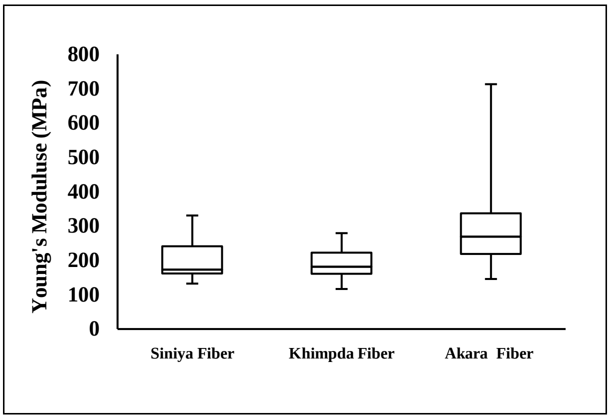


Fig. 5: Young's Modulus of the three distinct fibers.

From the low values of tensile character, for these light weighted natural fibers tie based rope can be manufactured which may be perishable in nature with the time when bound with soil. (Ashby, 2005). Therefore, matting and geotextile manufacturing using these environment friendly natural fibers can be possible (CB, 2007). Soil binding capability and Stiffnesss also allows the locally manufacture cheap ropes to be used for manufacturing slow release composite geotextile mats (Rajkumar, 2017).

5. CONCLUSION

The tensile properties of three strand ropes of *Siniya, Khimpda, Akara* have been manufactured and investigated. Among all the natural fibres tested, *Siniya* registered the highest tensile strength properties whereas *Akara* showed the highest Young's Modulus. Natural geotextile requirement, rising costs and environmental issues has led to investigate these natural sustainable materials that may replace synthetic polymeric fibers (Silva *et al.* 2008). These natural fibers are a local effective alternative since they are locally available and can be extracted from plants at very low costs. Each and every geographic region has a plant material (if investigated) which can be developed to replace synthetic polymers and plastic ropes.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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