FEASIBILITY OF DEVELOPING BANANA-COTTON FABRIC AS A SUSTAINABLE TEXTILE

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ABSTRACT

Agro-based fibres for textiles are trying to substitute conventional fibres in some form as blending with other fibres or by themselves. Studies showed that fibres from banana pseudostem possess beneficial qualities that can be used for textiles. They are to be treated to carry out the spinning process and woven into a fabric as they possess considerable stiffness. Banana-cotton mixture or blended fabric is most suitable because both are cellulose in nature, and blending can be done homogeneously. The biodegradability of banana fibres and its availability as an agro waste can be considered as a sustainable source for textiles. This study conducted in the year 2019 attempted to find out the feasibility of using banana fibre to produce yarn and then weave it into fabric in an eco-friendly process. The woven material was evaluated for its physical properties. This could further be used for different end uses, can be produced on a larger scale and provide scope for the development of rural employment.

Keywords: Agro-waste, Banana fabric, Banana fibre, Banana pseudostem, Eco fabric, Natural fibre

INTRODUCTION

India has abundant sources of natural fibre. There is plenty of scopes to explore and use natural fibres in traditional methods and provide to the consumers' needs (Pappu et al., 2015). The potential of utilizing non-conventional fibres from nature on a regular basis needs to be studied.

Banana fibres being agricultural residues, have the advantage over others. Banana as a fruit crop is called kalpatharu. It belongs to the Musa family, particularly M. acuminate (Sucharita and Vasugi, 2018).

In the banana plant, after fruits are harvested, a large quantity of pseudostem, leaves and suckers are generated (Vigneswaran et al., 2015). Pseudostem of banana that provides fibre are usually disposed of as waste after banana cultivation. Banana fibres are biodegradable, and being natural fibres, products made from them are in demand in the market at the global level. They are non-toxic,
and their production does not affect man or the environment. At present, banana fibres are used for making handicraft products in the cottage industry. In countries such as Japan and Nepal, banana fibres are used in making textile products and accessories. Most research is being done on developing woven fabric and non-woven composites from banana pseudostem fibres. Banana fibre is a natural fibre with high mechanical properties which can be blended easily with various other fibres or materials (Ramachandran et al., 2016). Banana fibres are available year-round and also affordable. This creates good market potential and has scope for export. In India, products from banana fibre are made on a small scale though being one of the largest banana producers. The potential of banana pseudostem fibre has not been fully utilized despite its abundant availability. The use of this fibre in textiles is limited in application as it has high stiffness and less spin ability. The fibres obtained from banana pseudostem need to be softened to produce yarn. Generally, chemicals are used to treat and soften them to spin or blend into a yarn, which is not eco-friendly. Hence an eco-friendly method of treating the banana fibre into a fabric should be followed for the fabric to be eco-friendly and sustainable. This will help generate farmer income, provide better opportunities, and develop agro-based rural industries.

MATERIALS AND METHODS

Selection of fibre

Banana fibre has emerged as a new eco-friendly fibre since it is produced from banana pseudostem, as a waste material after harvesting the banana fruit as an agricultural residue (Ortega et al., 2016). Banana fibre can be spun to produce yarns, mixed or not mixed with other fibres. Banana fibres are used in building materials and also in textile materials (Vinoth et al., 2018). The fibres are longer, have tensile strength and can provide more yarns. These fibres can be blended with other natural or synthetic fibres (Sarma and Deka, 2016). This study was conducted in the year 2019 attempted to weave fabric using yarn made from banana fibres. Bananas being an all-season crop, produce a considerable mass of pseudostem waste throughout the year, providing a regular supply of raw material for fabric production. Cotton is versatile in nature; its appearance, performance and comfort properties make it an important fabric in our daily life. It can be blended with many other fibres and contribute to the characteristics of the blended yarns and fabrics. Cotton and banana yarn were used for the study. Banana pseudostem fibres are biodegradable and thus can be categorized as environment-friendly. Banana pseudostem fibre can be spun using almost any method of spinning (Subagyo and Chafidz, 2018).

Softening of Banana fibres

Banana fibres were extracted from pseudostem by hand as per the procedure suggested by Sucharita and Vasugi (2018). Banana fibres extracted from pseudostem contain pectin and hemicelluloses. After extraction, degumming banana fibres is essential for the removal of gummy materials that are non-cellulosic. The degummed fibres were dried well to remove moisture (Sarma and Deka, 2016). The fibres have limited use in textiles because of their high stiffness and less cohesive properties. Banana fibres treated with chemicals such as alkali and peroxide show considerable weight loss (Doshi and Karolia, 2016).
Treating fibres with a high concentration of caustic soda resulted in fibre damage and further led to shrinkage in length (Subashini et al., 2020). The banana fibres softened with castor oil, cotton seed oil and soap reduce their flexural rigidity (Tholkappiyan, 2016). Banana fibres need to be treated to reduce their stiffness. First, the fibres were rinsed in water and boiled for five minutes. Then the fibre was softened by boiling in five per cent castor oil and a few drops of wetting agent for one hour. The material liquor ratio of 1:20 was followed. The treated fibres were rinsed in a non-ionic soap solution and again boiled in water for five minutes. The treated fibres were then dried completely under shade.

Weaving of Banana fabric

Spinning Banana Fibres: The treated and dried fibres were loosened and cut into small lengths of about five inches, arranged parallelly

Figure 1a. Hand-spun banana yarn  
Figure 1b. Fabric -1 (F1)  
Figure 1c. Fabric -2 (F2)

Figure 2. Flow chart depicting softening banana fibre to banana fabric weaving
and spun manually. The spun yarn was tested for its Yarn strength and elongation using IS: 1670:1991 standards and Yarn twist using IS 832: 1985. The yarn strength tests were carried out in Textile Committee, Coimbatore.

Weaving banana yarn to fabric: The hand-spun banana yarn was then woven into fabric. Banana-cotton mixed fabric weaving was carried in handloom. Two fabrics were produced, namely Fabric one (F1) and Fabric 2 (F2). F1 was made with 100% banana yarn in both warp and weft direction, and F2 was a cotton banana mixture fabric with banana yarn in the weft and cotton yarn in the warp. Cotton yarn used for weft is 20s/2 count yarn with an S twist. The woven fabrics were then evaluated for their properties.

Evaluation of mechanical properties of softened banana fibre

Untreated and softened banana fibres were tested for single-fibre tensile strength and elongation per cent. The fibres were tested at standardized conditions of 21°C ± 1°C temperature and 65% ± 2% relative humidity. The test was done in SITRA, Coimbatore, using a Zwick roell strength testing instrument with 1kN load, gauge length of 50 mm and a speed of 10 mm/min.

Analysis of woven fabrics

Physical and mechanical properties of banana fabric: Woven banana fabric was analyzed for its thickness, count and strength. The thickness of the fabric was measured with a thickness tester using ASTM-D1777-96 (2015) test method. The fabric was stretched out on the flat area below the pressure foot without wrinkles and face side up. Pressure was applied on the test fabric for 5 to 6 seconds until full pressure was reached, and then the thickness was recorded in mm. The thickness of the fabrics was noted at different points, and the average was calculated.

Fabric count is the determination of the number of threads or ends, and picks per unit length of the fabric are very important for the analysis of the fabric. The fabric count was done using pick glass. The tensile strength of the fabrics was tested following ISO 13934-1-2013 standards. It is evaluated by stretching the test samples to their breaking point.

Absorbency test: The absorbency test was conducted to measure the time taken by the fabric to absorb a drop of water. The absorption of the droplet by the fabric varies according to the thickness of the fabric. The drop
test was carried out according to AATCC Test Method 79-1995.

RESULTS AND DISCUSSION

Mechanical properties of banana fibre

Single fibre strength was carried out for banana fibres. The strength of the treated fibres had a significant decrease when compared to raw fibre. The softening treatment has reduced fibre strength by twenty-five per cent. The graph of strain% for breaking strength of raw and treated fibres are given in figure 3 and figure 4.

The results of the mechanical properties of banana fibres are presented in Table 1. The mean elongation of the softened fibres had increased. This could be due to the oil, which had softened the fibre. The tenacity of softened fibre has increased as a result of an increase in fineness. There is an improvement in fibre fineness after the softening process. The fineness had increased by around twelve per cent. Earlier studies showed that the chemical treatment of banana fibre changed from 140 Denier to 90 Denier (Tholkappiyan, 2016)

From the above table, t-test analysis shows significance at a 1% level for breaking strength, breaking elongation % and fibre fineness between raw and softened banana fibre.

Table 1. Mechanical properties of raw and softened banana fibre

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Properties Samples</th>
<th>Mean Breaking Strength(gf)</th>
<th>Mean Breaking Elongation %</th>
<th>Tenacity (g/den)</th>
<th>Fibre Fineness (Denier)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw Fibre</td>
<td>598</td>
<td>1.6</td>
<td>1.54</td>
<td>387</td>
</tr>
<tr>
<td>2.</td>
<td>Fibre treated with Castor oil</td>
<td>441</td>
<td>2.0</td>
<td>1.75</td>
<td>252</td>
</tr>
</tbody>
</table>

Table 2. Statistical analysis for mechanical properties of raw and softened banana fibre

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>T-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mean Breaking Strength (gf)</td>
<td>Raw Fibre</td>
<td>598</td>
<td>1.58</td>
<td>.71</td>
<td>157.0 .004*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fibre treated with Castor oil</td>
<td>441</td>
<td>1.58</td>
<td>.71</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Mean Breaking Elongation %</td>
<td>Raw Fibre</td>
<td>1.6</td>
<td>.16</td>
<td>.07</td>
<td>-4.0 .004*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fibre treated with Castor oil</td>
<td>2.0</td>
<td>.16</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Fibre Fineness (Denier)</td>
<td>Raw Fibre</td>
<td>387</td>
<td>1.58</td>
<td>.71</td>
<td>135.0 .000*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fibre treated with Castor oil</td>
<td>252</td>
<td>1.58</td>
<td>.71</td>
<td></td>
</tr>
</tbody>
</table>

*= Significant at 1% level, **=Significant at 5% level, NS = Non-Significant
indicates that there is a difference after the raw fibre was treated with castor oil and a wetting agent.

**Hand-spun banana yarn analysis**

The properties of hand-spun yarn produced using the softened fibres are presented in Table 3. The yarn produced had three twists per inch in the ‘Z’ direction. The yarn count was less than one. Though the yarn was rough, the softening of banana fibres with castor oil improved its spinability when compared to raw fibre, which was difficult to be spun.

**Table 3. Analysis of banana single yarn**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Yarn properties</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Twist per inch</td>
<td>3.2</td>
</tr>
<tr>
<td>2.</td>
<td>Twist Direction</td>
<td>Z</td>
</tr>
<tr>
<td>3.</td>
<td>Yarn count</td>
<td>0.63s Ne</td>
</tr>
<tr>
<td>4.</td>
<td>Single yarn strength</td>
<td>10.4 Kg</td>
</tr>
<tr>
<td>5.</td>
<td>C.V.% of yarn strength</td>
<td>24.6</td>
</tr>
<tr>
<td>6.</td>
<td>Elongation % at break</td>
<td>6.1</td>
</tr>
<tr>
<td>7.</td>
<td>C.V.% of elongation</td>
<td>19.9</td>
</tr>
</tbody>
</table>

**Evaluation of woven banana fabric**

The evaluation of the properties of woven banana fabric samples is presented in Table 4. The fabric count of F1, which was banana yarn on warp and weft, was less than that F2, which is a mixture fabric with cotton yarn along the warp direction. The number of yarns per inch in F1 may be less due to the thickness of the yarn, as the hand-spun banana yarn was used in both the warp and weft directions. In the F2, the cotton yarn utilized for warp was thin, and this caused the closeness of banana yarn along the weft direction also. The thickness of banana yarn has reduced the fabric count in F1. The fabric thickness of F1 was found to be higher than F2, which might also be due to the yarn thickness. Similarly, the fabric weight of F1 was also higher than F2.

The air permeability of F1 was much higher than F2 due to the porous construction of the fabric. The tensile strength of the F1 warp direction was less than the weft direction, which is not usual in a textile material. Similarly, the...
tensile strength of the warp direction in F2 was much lesser than its weft direction. This indicates that the banana yarns have good tensile strength. Similar results were noted in the study conducted by Sucharita and Vasugi, (2018), where the tensile strength in the warp direction was less than that of the weft in which the banana fibre was used. The absorbency was quicker in F1 due to its porous construction. In comparison, F2 had lesser absorbency than F1, as the yarns were arranged closer.

Table 5 showed the t-test analysis between Fabric 1 and Fabric 2. The statistical analysis of the values for F1 and F2 showed that there is statistical significance at a 1% level in fabric GSM, fabric thickness, tensile strength and absorbency of the two fabrics.

### CONCLUSIONS

Banana fibre being an agro waste and eco-friendly natural fibre, can be a substitute for synthetic fibres in the textile industry. Researchers say that if produced on a large scale, it can be a cheaper and more sustainable alternative to conventional natural fibres. The fibre can be softened and spun into yarn through an eco-friendly process. Usually, chemicals are used to soften the banana fibre. The use of castor oil is an eco-friendly way to soften the fibre for spinning and was found to be effective. The properties of banana cotton mixture fabrics show that they can certainly be used as an effective textile material. The thickness and strength of the developed fabric show that it has a prospect of being used in packaging and home textiles. The banana fabric produced may be used as backing material for home textiles such as carpets and rugs. This may help create employment for rural people in fibre extraction. The fabrics made using banana fibre will certainly be eco-friendly materials and sustainable fabrics of the future.
REFERENCES


