DEVELOPMENT AND CHARACTERIZATION OF HERBAL-FINISHED BANANA/COTTON BLENDED FABRIC FOR SUSTAINABLE YOGA MATS

Original scientific paper
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ABSTRACT: *The ultimate aim of the paper is to develop a yoga mat using different blends of banana with cotton. By using these blended yarns the woven fabric is produced and the produced fabric is taken for pre-treatment process by using soapnut and charcoal to remove the natural impurities present in the fibre and then the fabric is dyed with eco–friendly natural dyes also the eco-friendly natural dyed fabric is printed with Azadirachta indica and Ocimum tenuiflorum. Treated fabric is tested for the comfort and aromatic properties and then taken for manufacturing. The manufactured product contributes to comfort, hygenic, thermal and ecological factor.*

Keywords: *Banana/Cotton Blended fabric, eco-friendly natural dyed fabric, Azadirachta indica, soapnut, Ocimum tenuiflorum, Yogamat Fabric.*

RAZVOJ I KARAKTERIZACIJA TKANINE OD BANANE I PAMUKA OBRAĐENE BILJNIM MATERIJALOM ZA ODRŽIVE PROSTIRKE ZA JOGU

APSTRAKT: Krajnji cilj rada je razvoj prostirke za jogu koristeći različite mešavine banane i pamuka. Korišćenjem ovih mešanih pređa proizvodi se tkana tkanina, koja se podvrgava procesu prethodne obrade pomoću sapunskog oraha i uglja kako bi se uklonile prirodne nečistoće prisutne u vlaknima. Zatim se tkanina boji ekološki prihvatljivim prirodnim bojama. Takođe, ekološki prihvatljiva prirodno obojena tkanina se štampa sa Azadirachta indica i Ocimum tenuiflorum. Obrađena tkanina se testira na udobnost i aromatična svojstva, a zatim se koristi za proizvodnju. Proizvedeni proizvod doprinosi udobnosti, higijeni, termičkom i ekološkom faktoru.

Ključne reči: Tkanina od mešavine banane/pamuka, ekološki prihvatljiva prirodno obojena tkanina, Azadirachta indica, sapunski orah, Ocimum tenuiflorum, Tkanina za prostirku za jogu.

1. INTRODUCTION

Clothing and apparel products made of synthetic fibres like polyester and nylon adds to microplastic pollution, which can end up in the ocean and pose a hazard to marine life. Each year, 1.5 million tonnes of microplastics wind up in the ocean, with synthetic fabrics accounting for 35% of the total. Apparel is the most basic requirement for human survival in this environment. However, we are in a predicament where we must save our planet, 'THE EARTH.' Synthetic fibres, on the other hand, pollute the environment in a variety of ways, including contaminating the air, affecting the ecology, and so on. In this situation, the entire world is moving away from environmentally friendly and sustainable fashion. Customers are becoming more environmentally mindful as well. As a result, there is a high demand for sustainable items on the market.

2. LITERATURE REVIEW

2.1. Selection of material

Natural fibres are increasingly used in composites due to their inexpensive cost and outstanding mechanical qualities. These are promising prospects for the development of agro-based fibres. Banana fibres have a great potential as a natural fibre among the existing agro-based, natural cellulosic fibres. Its long-term viability is clear, and it offers untapped potential in the textile industry. There are several options in India for extracting fibres from banana stems [1].

2.2. Banana production and availability

Musa acuminata (banana) is a Musa species. Banana cultivation is a prominent agricultural activity in India since it is a valuable fruit crop. The wide area of cultivation that can offer a substantial amount of fibres produces a large amount of trash [2]. Various portions of the banana plant, such as banana skins, leaves, and stems, produce around that are not directly used. Banana pseudo-stems can produce fibres of various sizes. The pseudostem may produce 600 kg of fibre per hectare, which has been proven to be helpful for a variety of purposes [3].

2.3. Extraction of banana fibre

A machine that eliminates bark, skin, wood, stalks, grain from trees, hard to peel, is shown in Figure 1.

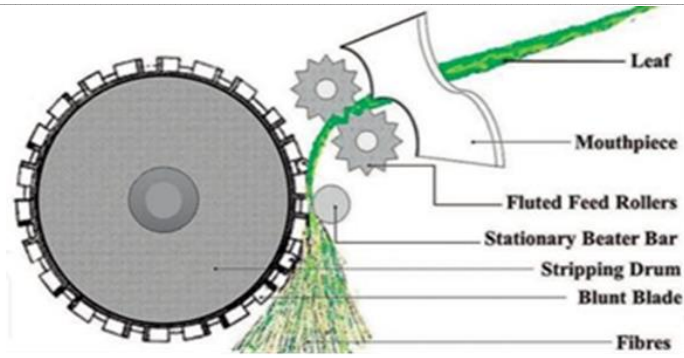


Figure 1: Machine for Pseudo stem extraction [5]

2.4. Characteristics of banana fiber

Banana fibre has a similar appearance to bamboo and ramie fibre, but its fineness and spinnability are superior to the two. It can be spun in a circle using practically any method, including ring spinning, open-end spinning, bast fibre spinning, and semi-worsted spinning, among others [3].

2.5. Application of banana fiber

Banana plants are the best source of fibre, as well as having several additional purposes such as therapeutic, alcohol, starch extraction, and many more[4]. This banana fibre is used to make high-quality textiles in Japan and Nepal [5]. Banana fibres are mostly used to make marine cordages, cardboards, tea bags, string thread, fabric material, and tying rope. In Japan, banana fibres are utilised to make traditional ceremonial robes [5]. In Nepal, the plant's outer sheath is used to make place mats, floor mats, and sun screens.

2.6. Banana fiber structure and properties

Banana fibres contain robust walls that are held together by hemicellulose, pectin, and lignin [6]. The "pith" is the section of a sheath that isn't made of fibre. Taking the pith out of the banana sheaths, on the other hand, has no effect on the content of the fibre strands, but it does liberate fibres from the sheath [7].

Table 1: Fiber components of Banana [8]

Fiber	**Banana**
Cellulose(%)	60-85
Hemicellulose (%)	6-8
Lignin (%)	5-10
Pectin (%)	2.5-4
Ash (%)	7-21

When degummed, the cell wall thickness of banana fibre measured 8.3 m, which was not substantially different from that of sisal (approximately 12.8 m) and ramie (about 11.5 m) according to some research [9,10]. The use of banana fibre in the textile industry is limited by its hydrophilicity, coarse fineness, poor elasticity, lack of cohesiveness, increased yarn unevenness, and hairiness [11]. Pretreatment and material preparation, on the other hand, can improve fineness and mechanical properties [12,13].

2.7. Cotton fiber production and availability

Various species of cotton grown as crops are native to most of the world's subtropical regions and have been domesticated many times independently. Within 80-100 days after planting, the plant blooms white flowers, which turn reddish. The fertilized flower falls after a few days and replaces it with a small green triangular pod called a ball. This pod matures in 55-80 days [14].

2.8. Extraction of cotton fiber

The cotton bundle is opened, and its filaments are raked precisely to eliminate unfamiliar matter (e.g., soil and seeds). A picker (picking machine) then, at that point, wraps the strands into a lap. A card (checking) machine brushes the free strands into lines that are joined as a delicate sheet, or web, and structures them into free untwisted rope known as card bit [15].

The methodology for meshing cotton yarn into texture is like that for different filaments. Cotton looms join the strained the long way yarns, called twist, with transversely yarns called weft, or filling. Twist yarns regularly are dealt with artificially to forestall breaking during weaving [16].

2.9.Degumming of banana fibre

Banana fibers obtained after the different degumming treatments was evaluated for the physical, chemical and mechanical properties so as to ascertain the effect of enzyme activity on the quality of treated fibers (Figure 2).

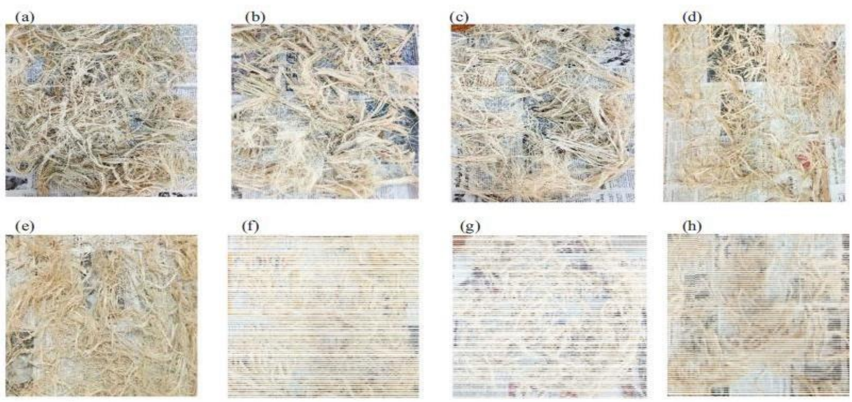


Figure 2: Segregation of fiber after degumming process (a), (b), (c) and (d) (T1-T4) are different enzymatic treatments in Red Banana variety and (e), (f), (g) and (h) (T1-T4) are treatments followed in Popoulu variety.

2.10. Spinnability of banana fibre

Once fibers were treated by enzymatic means and characterized, fibers were introduced into a lab-scale spinning plant. A Shirley opener for short fibre was used before introducing the fibers into the carding flats. The absolute humidity during fiber processing was 17 g/kg dried air, as previous experiences have shown that stiff fibers have better processability when working at high humidity rates. Due to the difficulty of banana fibers spinning, they were mixed with cotton, polyester and wool. Once the wick was produced, the following step was carried out in an industrial twist roving Electro-Jet .The spinning process took place in a continuous ring spinning machine. The yarn was then twisted in a ring twister, the filaments were twisted at 400 laps/m, in an S sense; and the spindles ratio was 2000 laps/min with a production of 5 m/min [17].

2.11. Weaving of banana and cotton blended of yarn

That plain 1/1 has recorded the high rates of fabric weight followed by twill 2/2 & satin 4 respectively. This is due to decreases the float length in weave structure lead to an increase in the number of intersections per unit area in the produced fabrics and increase the yarns crimp, as a result the fabric areal density increased [18].

2.12. Natural dyeing of banana and cotton blended fabric

Banana fibers, extracted from the sheath, can be utilized for manufacturing fiber, can diminish the pressure on the jute fiber. A Jute-Banana hybrid fabric (JBHF) was developed by using Jute yarn (12 Ne, in warp) and Banana yarn (18 Ne, in weft). In order to evaluate physico- mechanical properties of naturally dyed Jute-Banana hybrid fabric, different tests like Stiffness, Thickness, Tensile strength, Tear strength, Drape and Crease recovery were conducted which provided satisfactory results. Colorfastness to wash, water, rubbing and perspiration of naturally dyed Jute- Banana hybrid fabrics (JBHF) also provided acceptable outcomes. FTIR test also provided the confirmation of this two fibers and Spectrophotometer was used to illustrate the dyeing quality. It was an endeavor to minimize the dependency on a single quality fiber and find an alternative way to prepare the hybrid fabric by blending two different quality natural fibers. [19]

2.13. Madder

The creation and application of natural dyes, such as madder, has received increasing attention from various researchers as environmental protection awareness has grown. They are obtained from natural resources and renewable, and therefore, their uses will continue to inspire scientists due to their ecological, antimicrobial, and UV protection characteristics [20,21]

3. MATERIALS AND METHODS

3.1 Materials

In this study, Banana and Cotton fiber were used to made a sustainable yoga mat which is dyed with natural dyes madder and printed with neem and tulsi leaves.

3.1.1. *Banana fiber*

Banana Fiber is sourced from NRCB, Trichy, Tamil Nadu, India as shown in Figure 3. It consists of cellulose, hemicellulose, and lignin.

Figure 3: Banana Fiber

3.1.2. ***Banana fiber specification***

Banana fibres contain robust walls that are held together by hemicellulose, pectin, and lignin [6,22]. The "pith" is the section of a sheath that isn't made of fibre. Taking the pith out of the banana sheaths, on the other hand, has no effect on the content of the fibre strands, but it does liberate fibres from the sheath. Mechanical properties and specification of Banana Fiber are shown in Table 2.

Table 2: Mechanical properties and specification of Banana Fiber

Fiber	**Banana**
Fiber Diameter (μm)	8.3
Moisture content (%)	9.8-12
Density (g/cc)	1.350
Microfibrillar angle (◦)	11-15
Tensile strength (Mpa)	550±6.8
Fiber Denier(g/denier)	29.98
Fiber Length(mm)	10
Dry (g/tex)	34.86
Elongation %	2.40
Handle	Very coarse
Hydroscopic Nature	Absorbent
Young’s modulus	3.5

3.1.3. ***Cotton fiber***

Raw cotton fiber is sourced for Best Cotton Mill, Tirupur, Tamil Nadu, India. It is a natural cellulose fiber that has the natural Microbial activity.

3.1.4. ***Cotton fiber specification***

Specification and properties of cotton is shown in Table 3.

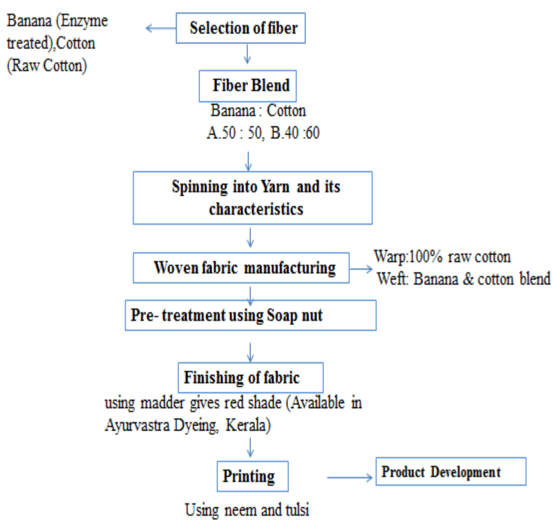
Table 3: Specification and properties of cotton

Fiber	Cotton
Fiber Diameter (µm)	10
Moisture content (%)	7.1
Density (g/cc)	1.5
Microfibrillar angle (◦)	10-12
Tensile strength (Mpa)	264-654
Fiber Denier(D)	2.0 D
Fiber Length(mm)	1.30mm
Dry (g/tex)	27-44
Elongation(%)	9.5%
Handle	Softer
Hydroscopic Nature	Super Absorbent
Young's modulus	5 to 12

3.2.Methodology

In the below flow chart explains the process of the Banana and cotton blended fabric to make home textile product.

3.2.1. *Flow chart*



4. TESTING

Testing ensures the safety, quality and performance of their goods. Tests can be carried out on items ranging from fibre samples to finished products.

5. RESULTS AND DISCUSSION

5.1. Yarn test

5.1.1. *Yarn count*

The yarn count of the yarn samples has been given in the above table. The result shows that both the blends have same count.

5.1.2. *Yarn twist per inch and twist direction*

The result shows that both the blends have 36 TPI and in S direction.

5.1.3. *Tensile strength*

The tensile strength of a B40:C60 shows good tensile strength than the B50:C50.Since the cotton fibre captured the high areal density than the banana because of its length and weight.

5.1.4 *Elongation*

As similar to the tensile strength, the B40:C60 shows good elongation than B50:C50 blend and the B50:C50 shows lower elongation than B40:C60.

5.2. Fabric testing

5.2.1. *GSM*

The B40:C60 blend shows high GSM than the other blend, Since the cotton can hold high areal density than banana.

5.2.2. *Thickness*

The thickness of the weaved fabric has been given in the table. As similar to the GSM, the B40:C60 shows higher thickness than B50:C50 blend and the B50:C50 shows lower thickness than B40:C60.

5.2.3. *Stiffness*

The B40:C60 shows higher stiffness than B50:C50 blend and the B50:C50 shows lower stiffness than B40:C60.

5.2.4. *Water vapour permeability*

The B50:C50 shows higher Water Vapour than B40:C60 blend and the B40:C60 shows lower Water Vapour than B50:C50.

5.2.5. *Tearing strength*

The B50:C50 shows higher Tearing Strength than B40:C60 blend in both warp and weft direction and the B40:C60 shows lower Tearing Strength than B50:C50 in both warp and weft direction. But, the variation is in very low deviation.

5.2.6. Air permeability

The B50:C50 shows higher Air Permeability than B40:C60 blend and the B40:C60 shows lower Air Permeability than B50:C50.

5.3 Natural dyed fabric testing

5.3.1 *Computer colour matching system*

The B50:C50 shows higher K/S value than B40:C60 blend and the B40:C60 shows lower K/S value than B50:C50.

5.3.2 ***Advanced crock meter (test for dyed)***

Both the blended sample possess a good and similar color fastness.

5.4 Natural printed fabric testing

5.4.1 ***Advanced crock meter (test for printed)***

Both the blended sample have a good and similar color fastness.

6. FUTURE SCOPE

This project is an attempt to find a better sustainable fibre and how good the fibre behaves when it undergoes through natural pre- treatment, dyeing and printing process. Further, we can make a good accessories like laptop covers, mouse pads, carry bags etc.., which will act as a replacement for harmful materials like plastic bags, polyester fibre etc.,

7. CONCLUSION

The B40:C60 blend shows good results and possess a required properties. Hence, the final product will be a sustainable yoga mat product made of B40:C60 which possess a good required properties and with an aroma that calmness to the mind. And also, this product will be an eco-friendly product.

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