STUDIES OF ANTIBACTERIAL PROPERTIES OF BANANA FABRIC BY DYEING WITH NATURAL DYES

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Abstract: *Natural fibres, which are always biodegradable, organic, and non-toxic, find wide demand in technical textiles. Banana, a cellulosic fibre acquired from the banana plant, is a natural fibre that contributes to conserving the environment. The present study envisages extracting banana fabric using natural dyes such as henna, turmeric, and indigo. The banana fabric was pre-mordanted with two types of mordants, i.e., copper sulphate and alum. The banana fabric was dyed with turmeric, henna, and indigo. The henna shows a brown colour, the indigo shows a light blue colour, and the turmeric shows a rich yellow colour. Among those three dyes, turmeric shows the best colour, i.e., a rich yellow colour, and it also shows good antibacterial properties.*

Keywords: natural dyes, banana fabric, turmeric, henna, indigo, fastness, antibacterial.

ISTRAŽIVANJA ANTIBAKTERIJSKIH SVOJSTVA TKANINE OD BANANE BOJENJEM PRIRODNIM BOJAMA

Apstrakt: *Prirodna vlakna, koja su uvek biorazgradiva, organska i netoksična, pronalaze široku potražnju u tehničkom tekstilu. Banana, celulozno vlakno dobijeno iz biljke banane, je prirodno vlakno koje doprinosi očuvanju životne sredine. Ova studija predviđa ekstrakciju tkanine od banane korišćenjem prirodnih boja kao što su kana, kurkuma i indigo. Tkanina od banane je prethodno obrađena sa dve vrste mordanta (fiksativa za boju), odnosno bakar-sulfatom i alumom. Tkanina od banane bila je obojena kurkumom, kanom i indigom. Kana ima braon boju, indigo svetlo plavu boju, a kurkuma bogatu žutu boju. Među te tri boje, najbolju boju pokazuje kurkuma, odnosno bogatu žutu boju, a pokazuje i dobra antibakterijska svojstva.*

Ključne reći: prirodne boje, banana tkanina, kurkuma, kana, indigo, postojanost, antibakterijski.

1. INTRODUCTION

Natural fibres are the essential alternatives in the ever-expanding horizon of textile fibres. They are non-toxic in nature; the disposal of fibre waste is easier as they are biodegradable. Natural fibres have excessive length-to-diameter ratios [1]. These fibres are bonded together by natural gums and resins. In textiles, natural fibres are mostly used in different areas and for different applications, mainly clothing, home furnishing, industrial textiles, and technical textiles [1].

Banana plants, including bananas, are critical parts of biodiversity, and their sustainable manipulation has become a valuable nourishment tactics. Currently, consumer understanding is progressively recommended natural antimicrobial characters and there is a growing study about antimicrobial resistance [2]. Secondary metabolites from plants provide as a shielding mechanism opposed pests and pathogens but may also be functional for other example medical applications. As antimicrobial resistance is quickly increasing,

new perspectives are important to complete the space in antimicrobial drug detection. Between several tactics, searching for story antimicrobial parts in plant extracts is charming, and the chemical variety of natural products is vast [2].

Banana, the cellulosic fibre obtained from the pseudo-stem of the banana plant *(Musa Sepientum),* is a basic fibre with good mechanical properties. It belongs to the family *Musaceae*. It is an herbaceous perennial plant, reaching a height of 3–9 metres. The banana plant is a massive herb with a succulent stem. The fibre is extremely strong and grows in hot climates [3]. Banana fibres have extremely strength, finer, smaller stretching, fire opposition quality, Powerful moisture absorption character, great Possibilities and biodegradability [5]. Banana fibre is similar in appearance to linen. It is light-weight, elegant in appearance, and easily washable [4]. Banana fiber has granted for textiles and home applications. Banana fiber has great possibilities for paper manufacturing special request of handcrafted paper. Banana fiber is manufacturing products like purify paper, paper covers, greeting cards, lamp stands, pen stands, decorative papers, rope, mats and composite material etc [5]. It is undyed, finer, softer, and more lustrous and porous than sisal fibre. Banana fabric is produced from the sheaths of the banana stem and then processed into yarn. The banana fabric is produced from 100 percent banana stem. The banana fabric undergoes certain processes, i.e., peeling of the bark into strips, which will be thin, and then it will be boiled in an alkaline solution that softens and dissolves the bark, followed by wet spinning and finally weaving the fabric. These banana fabrics are cool, sweat-absorbing, and breathable. The banana fabric is silky, non-irritating, soft, and safe to use.

The utilization of natural dyes and finishing process on textile has become significant due to the expanded natural attention to keep away unsafe synthetic dyes and chemicals. Even though the natural dyes are seen as a more secure option in contrast to synthetic dyes, they have the drawbacks: low variety yield, unfortunate reproducibility, and colour fastness properties [6]. The binomial nomenclature of turmeric is *Curcuma longa,* from the genus *Zingiberaceae*. Turmeric is commonly used in foods; it helps in improving immune function and also helps in curing many diseases, wounds, etc. It is antibacterial, antioxidant, and anti-inflammatory [7]. It is rich in phenolic compounds, which are called curcuminoids. Turmeric is used in preparing the dye solution that is used for dyeing, and it is more common and popular in natural dyes that are used in the textile industry. And India is the first-largest producer of turmeric in the world. It is also eco-friendly, and turmeric gives good, bright shades. In this research, turmeric has been used as a dye solution, which will be applied to banana fabric by following certain dyeing conditions [8].

Henna is commonly used for dyeing hair and cosmetics. Henna is a natural dye that can be used in the dyeing of textiles. Henna has both antimicrobial and antifungal properties. But for good and long-lasting colours, mordanting is required, which gives good results [9].

Indigo is a unique and different shade of blue. This Indigofera tinctoria shrub grows in tropical regions. These dyes are extracted from the leaves of the indigo plant, which gives them an eye-catching blue colour [10].

The dyeing of the banana fibre was done with myrobalan. The mordants used were alum, sodium chloride, and ferrous sulphate at concentrations of 10%, 30%, and 50% [11]. The dyeing of cotton fabric with marigold as a natural dye was also reported. This natural dye has antimicrobial and fasting properties [11].

In view of the supra, it was thought worthwhile to investigate the application of natural dyes such as henna, turmeric, and indigo on pre-mordanted banana fabrics and to produce baby mattresses from the natural dye, which produces better colours [12].

2. EXPERIMENTAL

2.1. Material

The fabric used here is power-loom banana fabric. It has cooling properties and will also be soft and supple. A burning test was done to identify the fabric. Ash came out by burning the fabric. So, it is concluded that it is a natural, cellulosic fibre. Turmeric *(Curcuma longa),* indigo *(Indigofera tinctoria),* and henna *(Lawsonia inermis)* were used for the preparation of dye solutions for dyeing. The ready-made banana fabric was taken. Turmeric was used to obtain a yellow colour; indigo was used to obtain a blue colour; and henna was used to obtain a brown colour. The mordants, such as potash alum and copper sulphate, were used.

2. 2. Methods

Turmeric was crushed into powder form. Two samples were taken and pre- mordanted with potash alum and copper sulphate separately. The mordants were freshly prepared by dissolving 5% in distilled water at ratio of 1:20. Sample gives rich yellow color. The fabric was crushed and twisted and air dried.

Indigo leaves were crushed into powder form. Two samples were taken. Samples were pre-mordanted with potash alum and copper sulphate separately. The mordants were freshly prepared by dissolving 5% in distilled water at ratio of 1:20. Sample gives blue color. The fabric was crushed and twisted and air dried.

Henna leaves were crushed into powder form. Two samples were taken. Samples were pre-mordanted with potash alum and copper sulphate separately. The mordants were freshly prepared by dissolving 5% in distilled water at ratio of 1:20. Samples give rich brown color. The fabric was squeezed and air dried. The flow chart of the process is shown below.

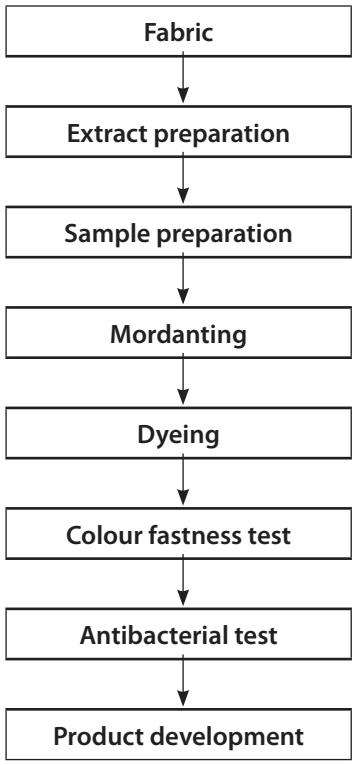

Figure 1: The flow chart of the process

2.2.1 *Scouring process*

The scouring of power loom banana fabric was done in a bath containing 3% sodium carbonate, 2% soda, and 1% surface-active agent, which is used to purify the banana fabric. This banana fabric will be immersed in the bath at 60°C for 30 minutes according to the liquor ratio of 1:20. The scoured banana fabric was dipped in normal water and dried under shadow. The scoured banana fabric was dipped in pure water for 30 minutes before going for mordanting.

2.2.2. *Pre-mordanting with alum*

Alum (potash aluminum sulphate) is the mordant used here. This pre-mordanting was done with a material-to-liquor ratio of M:L= 1:10. The temperature used was 70 °C for 60 minutes, along with a concentration of 10%. After this pre-mordanting, the sample fabric was taken out for dyeing. The fabric was not washed after this pre-mordanting. These samples were dried in the shadow.

2.2.3. *Pre-mordanting with copper sulphate*

The copper sulphate is used as a mordant here. This pre-mordanting was done with a material-to-liquor ratio of M: L = 1:10. The temperature used was 70˚C for 60 minutes along with the concentration of 10%. After this pre-mordanting, the sample fabric was taken out for dyeing. The fabric was not washed after this pre-mordanting. These samples were dried in the shadow.

2.2.4. *Dyeing procedure:*

Turmeric, henna, and indigo extracts were used for dyeing. First, the samples were weighed. The materials required were taken according to the M:L ratio (i.e., 1:20). The temperature was set to 60 °C, and 15 gallons of NaCl were added to the dyebath. Turmeric, henna, and indigo were extracted using distilled water and kept for 24 hours. The dye solution was kept in the dye bath and stirred using a magnetic stirrer. Then the six samples, which were pre-mordanted with alum and copper sulphate, were introduced to the dyebath, and the temperature was increased to 90 oC. The samples were then dyed for a period of 60 minutes with continuous stirring. Samples were taken out and washed in cold water. An antibacterial test was carried out on those dyed samples.

2.2.5. *Padding mangle*

The fabric was padded with a dye solution. Fabric was first dipped in the dye solution and then sent to the squeezing machine. The mangle squeezes out the extra dye solution from the fabric.

2.2.6. *Fastness properties*

COLOR FASTNESS PROPERTIES

Three types of fastness properties were evaluated: light fastness, wash fastness, and rubbing fastness.

LIGHT FASTNESS

This test was done by a light fastness tester.by following that grading in mentioned in Table 1. The sample, which was dyed with henna, turmeric, and indigo, was made into a 20*15 cm holder, and the sample was kept under xenon light for a period of 24 hours. After this, the fabric sample was removed

from the holder and assessed by the computer colour matching system.

Table 1: Grades based on the light fastness property

Grades	Range	Stages of fading
1	Very poor	Very much fading
2	Poor	Much fading
3	Moderate	Negligible fading
4	Good	Low fading
5	Better	Very low fading
6	Excellent	No fading

WASH FASTNESS

This washing fastness test was done by using a launder-o-metre and evaluation was done according to table 2. The sample, which is dyed with turmeric, indigo, and henna, was made into 15*6 cm in the ratio of 60:1. Two pieces of 10 x 6 pure white fabric were taken. Pure white samples were kept on the dyed sample, with half exposed to the sample and another half exposed. The samples were kept in a container with some solvents. For soaping treatment, the samples were taken to the launder-o-metre. After that, the samples were taken from the chamber and dried at 40 °C. Samples were compared and analysed using the grey scale value.

Table 2: Grade based on wash fastness property

Grades	Range
1	Poor
2	Moderate
3	Better
4	Best

RUBBING FASTNESS

The samples, which were dyed with turmeric, indigo, and henna, were made into sizes of 14 x 6 cm, and the white samples of 6 x 6 cm were taken. This rubbing fastness test was done using a crock metre. The grading was done by following table 3. In dry conditions, the fabric-dyed samples were rubbed against the pure white samples. Nearly 9 to 10 rounds were given to samples. After this, the sample that was rubbed was compared with the grey scale grade to find the range of staining. In wet conditions, the fabric-dyed samples were rubbed against the pure white samples. Nearly 9 to 10 rounds were given to samples. After this, the sample that was rubbed was compared with the grey scale grade to find the range of staining.

Table 3: Grades based on rubbing fastness property

Grades	Range of fastness
1	Poor
2	Moderate
3	Good
4	Extraordinary

2.2.7. *Antibacterial activity*

Assessment of antibacterial activity:

Qualitative method AATCC 147 and quantitative method AATCC 100 were used to determine the antibacterial activity of the dyed and undyed fabric.

Qualitative analysis:

Antibacterial activity of the sample was tested by AATCC 147- 2016 – Parallel streak method. The normal width of a zone of inhibition was determined.

The qualitative method was applied for the turmeric dyed fabric which was pre-mordanted with alum because the mordant alum shows the better colour when compared to copper sulphate.

Test Condition:

Test Organisms used	: *Staphylococcus aureus ATCC 6538, Klebsiella pneumoniae ATCC 4352*
Sample size	: Swatch of 25×50 mm for each bacterium
Media used	: Nutrient agar Incubation conditions: 37˚c for 24 h

3. RESULT AND DISCUSSION

Fastness properties of dyed samples are shown in table 4. Turmeric with alum shows the best fastness. The concentration was 10%. In wash fastness, the turmeric with alum shows grade 3, which is better. For the light fastness with a concentration of 10%, the turmeric shows grade 4, which is low fading. For rubbing fastness in dry conditions, the turmeric with alum shows 4-5, which is excellent. And also, in wet conditions, it shows 4, which is good. Based on the comparison of henna, turmeric, and indigo, the hen-

Table 4: Fastness properties of dyed samples

S. No	Mordant	Extracts	Wash fastness	Light fastness	Dry rubbing	Wet rubbing
1	Alum	Turmeric	3	4	3-4	3
		Henna	3	4	3	3
		Indigo	2	3	2	2
2	Copper sulphate	Turmeric	3	4	3-4	3
		Henna	2	4	3	2
		Indigo	2	4	2	2

Table 5: Antibacterial activity by using qualitative method

S. No	Particulars	Extract	Zone of inhibition in mm	
			Staphylococcus aureus	Klebsiella pneumonia
1	Untreated fabric	-	3 mm	2 mm
2	Pre-mordanted with Alum	Turmeric	12 mm	9 mm
3	Pre-mordanted with Copper sulphate	Turmeric	11 mm	8 mm

na and turmeric show good light, wash, and rubbing fastness. Turmeric is even better than henna with a concentration of 10% copper sulphate and alum.

Antibacterial test was taken for henna, turmeric and also for indigo with two bacteria such as *Staphylococcus Aureus* (Gram positive) and *Klebsiella Pneumonia*.(Gram negative) In qualitative method. Results are exhibited in Table 5. The antibacterial test was made with alum, the turmeric inhibits 12 mm in *S. Aureus* and 9 mm in *K. Pneumonia*. With copper sulphate, the turmeric exhibits 11 mm in *S.Aureus* and 8 mm in *K. Pneumonia.*

In qualitative method, the turmeric which was pre-mordanted with alum inhibited bacteria i.e., 12 mm for Staphylococcus aureus and 9 mm for Klebsiella pneumonia. Natural dyes such as turmeric, henna, and indigo are much cheaper. So, it will be cost-effective. But the banana fabric is quite expensive. However, the banana fabric is biodegradable, has cooling properties, etc.

4. CONCLUSION

In this paper, natural dyes such as henna, indigo, and turmeric were used. Among those dyes, turmeric shows better colour and also provides antibacterial activity. Turmeric shows better results compared to henna and indigo. The banana fabric has good absorbency compared to other fabrics, and it is eco-friendly, harmless, and safe to use. The banana fibre is used in many ways, such as currency notes, tea bags, etc. Alum with turmeric dye shows a better colour. In light fastness, the turmeric and henna show the better result, i.e., grade 4, and in wash fastness, the turmeric shows the better result, i.e., grade 3. In dry rubbing, the turmeric shows grade 3–4, and in wet rubbing, the turmeric shows grade 3, i.e., 3. In the qualitative method, the turmeric, which is pre-mordanted with alum, inhibits bacteria, i.e., 12 mm for S. aureus and 9 mm for Klebsiella pneumonia. The turmeric and alum-dyed fabric was made into the final product, i.e., the baby mattress, which was soft and supple.

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