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Utilization of tea residue for coloration of wool/acrylic blended yarn

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ABSTRACT

Natural dyeing has regained its popularity in order to keep the environment clean and safe by reducing the use of harmful chemicals in the dyeing process. Consequently, different natural dyestuff has been used in textile coloration: marigold, henna, onion skin, roots, and tree bark. Among these dyestuffs, tea has been used for the coloration of textiles. Around the world, including Bangladesh, a lot of tea is consumed on a daily basis. After consumption, the tea residue is disposed of in open spaces, which is considered a source of environmental pollution. Due to the adverse effect on the environment, this experiment used tea residue to dye wool/acrylic blended yarn to make the dyeing process more eco-friendly. Four different mordanting agents were used to determine the one most suitable for dyeing wool/acrylic blended yarn using tea residue. To evaluate the performance of the dyed yarn, the color-coordinate value and different colorfastness properties were measured.

1. Introduction

Textile coloration with synthetic dyes was initiated in the market in 1856 following the invention of the first synthetic dye, namely mauvine. The popularity of these kinds of dyestuff has peaked due to its accessibility, numerous reproducible shades, and easy application process [1,2]. The use of natural dyestuff is quite impressive but has one major obstacle: most artificial dyes require a lot of salts, alkali, or other harmful chemicals [3]. Sometimes, the fabric is treated with cationizer to curtail the use of salt during the dyeing process [4], which threatens environmental security. On the other hand, harmful dyes along with various chemicals can cause skin cancer besides harming the environment. The demand for natural dyes has gained popularity again, and the application of natural dyestuff has been enhanced. Apart from that, colors from natural sources are non-toxic, biodegradable, and non-carcinogenic [5-7]. Therefore, various renewable materials like root, bark, and leaves are applied for creating a coloration effect on fabric [8-14]. The future natural dyestuffs are economically and environmentally friendly, which can be beneficial for exporting the textiles product to various countries. Tea residue is one of the natural dyestuffs that has been used for coloring textile substrate [15-18]. But its application can accelerate dyeing costs, which is the ultimate concern of any textile industry. Additionally, so much waste is being produced by thousands of tea bags left in open spaces. Limited work has been done with tea residue [19], especially for blended yarn. It is a new approach for natural dyeing, while in most cases, natural dyes are applied to solid fabric. So, for dyeing blended yarn, we have to choose synthetic dyes with the many drawbacks previously mentioned. In this experimental study, tea residue has been used to dye the wool/acrylic blended yarn, which will serve the commercial purposes of the textile sector and abate wastage to make our country a more hygienic place. Also, four metallic mordants are used to determine which mordant is compatible for dyeing wool/acrylic blended yarn with extracted tea residue in respect of color coordinates and colorfastness properties.

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2. Materials and methods

2.1. Materials

The dye solution was extracted from tea residue (approximately 20g). The mordant weight was 10% of the fabric; four mordants, including alum, potassium dichromate, copper sulphate, and ferrous sulphate, were taken from the Textile Engineering Lab of the Primeasia University for pre-mordanting the wool/acrylic yarn, which was previously purchased from Mithila Chemicals Ltd.

2.2. Methods

2.2.1. Extraction of natural dye

Tea residue was collected from a residential area where it had been discarded; then, it was dried in the sunlight. Approximately 20g of tea residue was added to 1000 ml of water, and after that, boiled for 1 hour. During the boiling process, colorant from the tea residue was transferred to the water to produce a complete dye solution. Around 200 ml dye solution was collected after boiling. Subsequently, the obtained dye solution was used for dyeing the wool/acrylic yarn using mordanting agents.

2.2.2. Mordanting of wool/acrylic yarn

Scoured and bleached wool/acrylic yarns were pre-mordanted separately with alum, ferrous sulphate, copper sulphate, and potassium dichromate with similar concentrations (10%) at room temperature for 24 hours, keeping the material-to-liquor 1:20. The pre-mordanted fabric was then used for dyeing without any washing.

2.2.3. Dyeing of mordanted wool/ acrylic yarn with natural dye

With or without pre-mordanted wool/acrylic yarn was dyed with the extracted dye solution from tea residue. The recipe for dyeing is given as follows:

Yarn weight	3 g
Natural dye solution	0.1 g/ml
Mordanting agent	10%
Temperature	60^0 C
Time	60 minutes
M: L	1: 20

2.3. Different testing process

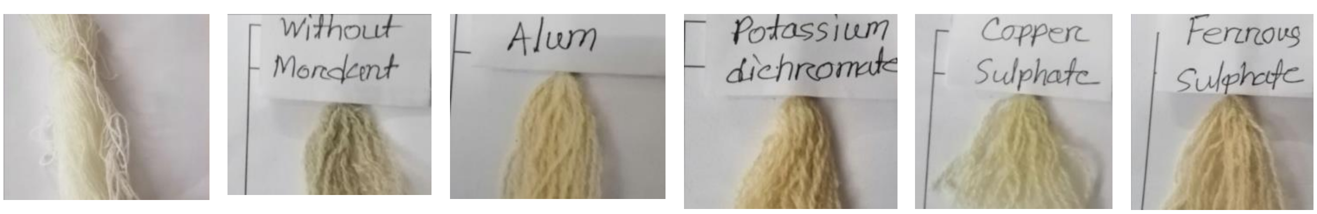
In order to evaluate the dyeing performance of the dyed yarn, the color co-ordinate value and color strength were measured by following CIELAB and CIELCH methods [20,21]. On the other hand, colorfastness properties were assessed by various colorfastness tests: colorfastness to washing, colorfastness to water, and colorfastness to rubbing.

3. Results and discussion

3.1. Visual appearance

It is observed in Table 1 that the wool/acrylic yarn dyed with the dye solution obtained from the tea residue provides a light color. After dyeing, it is prominent that the yarn dyed with only the dye solution yields a blackish-brown color. But the yarn dyed with residue tea solution pre-mordanted with alum, potassium dichromate, and copper sulphate provides a brownish color. The yarn pre-mordanted with ferrous sulphate yields a reddish-brown color due to the coordination of the original color of ferrous sulphate, which is red. On the other hand, the dyed yarn mordanted by potassium dichromate gives a slightly brighter color than the yarn mordanted by alum and copper sulphate because these are not compatible with the dye solution and wool/acrylic yarn.

Table 1. Pictorial view of dyed wool/acrylic blended yarn with tea residue.



Bleached yarn	S1	S2	S3	S4	S5

3.2. Color coordinate value

From Figure 1, it is clearly seen that wool/acrylic yarn dyed with the dye solution derived from the tea residue without mordant yields a low lightness value that is 69.34. On the other hand, a 78.21 lightness value has been observed for the yarn dyed with tea residue in the presence of the alum mordant. The pre-mordanted yarn using mordant potassium dichromate exhibits a 71.98 lightness value after dyeing with the tea extract solution. Moreover, Figure 2 shows that the value of a* is higher for yarn dyed in the presence of potassium dichromate, and as a result, it falls on the hue of 69.67, which is the reddish zone of the color wheel. Here, it is clearly seen that dyed yarn with bright color exhibits lower lightness value and vice versa. Additionally, S3 means the dyed yarn mordanted with potassium dichromate provides a higher value of redness (+a). For this reason, it gives a reddish-brown color to the dyed yarn.

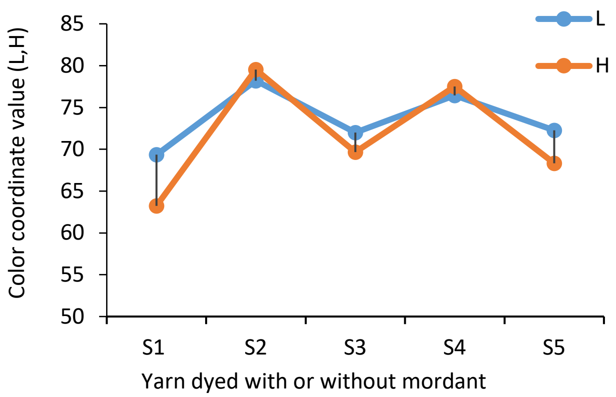


Fig. 1. Lightness (L) and Hue (H) value of wool/acrylic dyed yarn.

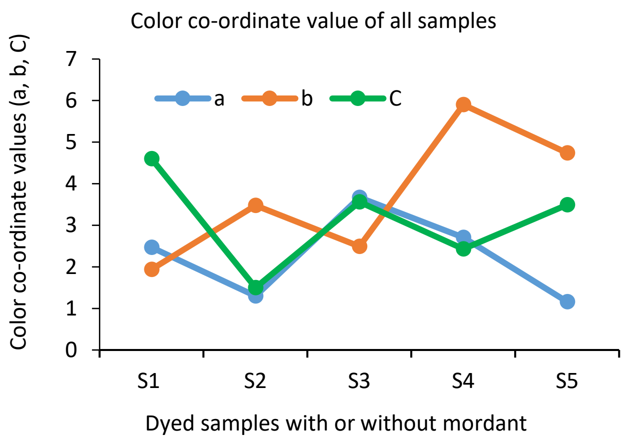


Fig. 2. Color coordinate (a, b, c) value of wool/acrylic dyed yarn.

3.3. Evaluation of color strength

Since color strength depends on reflectance, the more the value of the reflectance, the higher the value of the color strength. As a result, the dark sample has a higher color strength, and the light shade of fabric has a lower K/S value (Figure 3). In this regard, wool yarn dyed without mordant (S1) has a 29.95 color strength value due to the presence of polyphenols in the tea residue, which has the ability to dye fabric. But the yarn dyed with tea residue pre-mordanted in the presence of potassium dichromate (S3) exhibits a higher color strength value of 29.95, as potassium dichromate can enhance the dyeing ability of the polyphenols of tea residue.

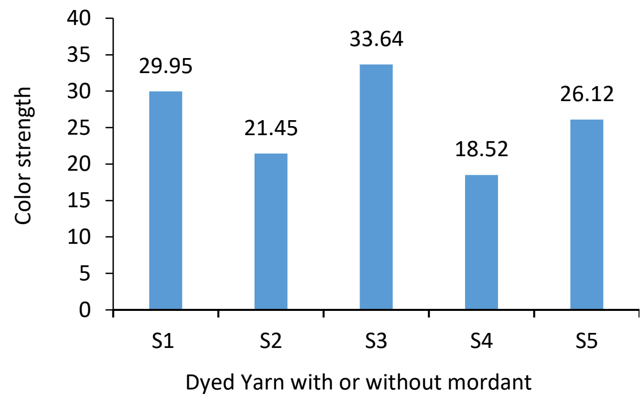


Fig. 3. Color strength of wool/acrylic dyed yarn

3.4. Colorfastness to wash

From Figure 4, it is observed that yarn dyed with tea residue yields outstanding results in the case of color staining to wash for all the samples treated with or without mordants, which is rated 4-5. In contrast, the yarn that is dyed without mordant and mordanting with potassium dichromate yields a colorfastness rating of 4 in terms of wash fastness, which is clearly seen in Figure 5 and is acceptable. And the reason for the 0.5 deductions of the colorfastness of these two dyed yarns is the higher depth of color compared to the other dyed yarns.

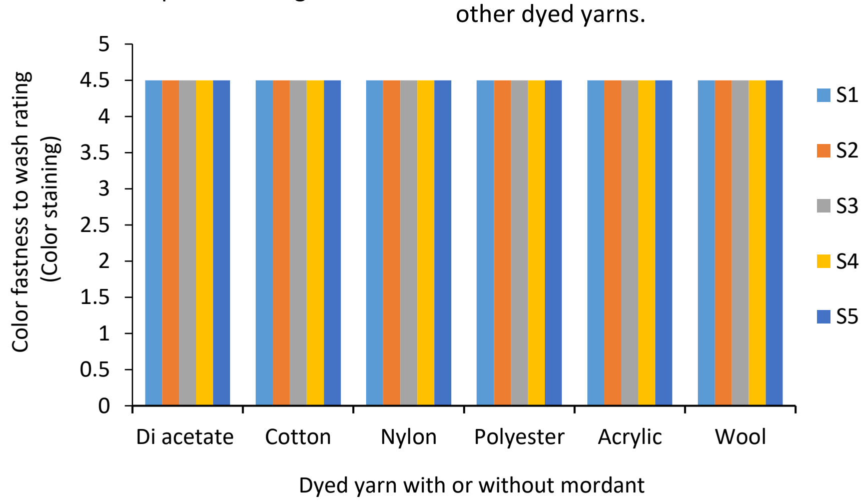


Fig. 4. Colorfastness to wash (Color staining) of dyed yarn with or without mordant.

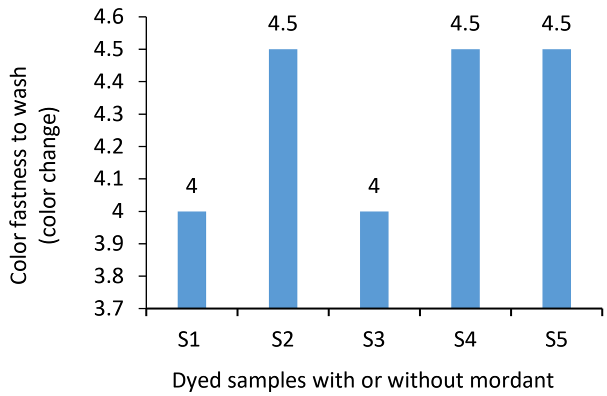


Fig. 5. Color fastness to wash (Color change) grading of dyed yarn.

3.5. Colorfastness to Water

For all specimens, there is no variation of the color change of water fastness, but in the case of color staining, water fastness is better (4-5) for the yarn dyed with the extracted dye solution before treatment with alum (Figure 6). But, fabric pre-mordanted with potassium dichromate exhibits a comparatively lower fastness rate after dyeing with tea residue that is shown in Figure 7. As mentioned earlier, samples S1 and S3 consumed a higher depth of shade, but that can degrade color in the presence of water by hydrolyzing the dye solution during dyeing.

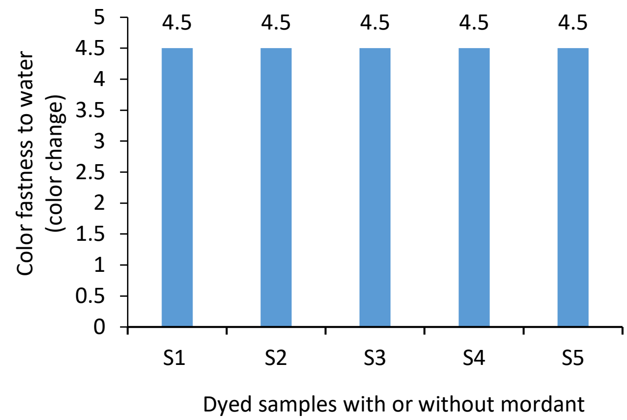


Fig.6. Colorfastness to water (color change) of dyed yarn with or without mordant.

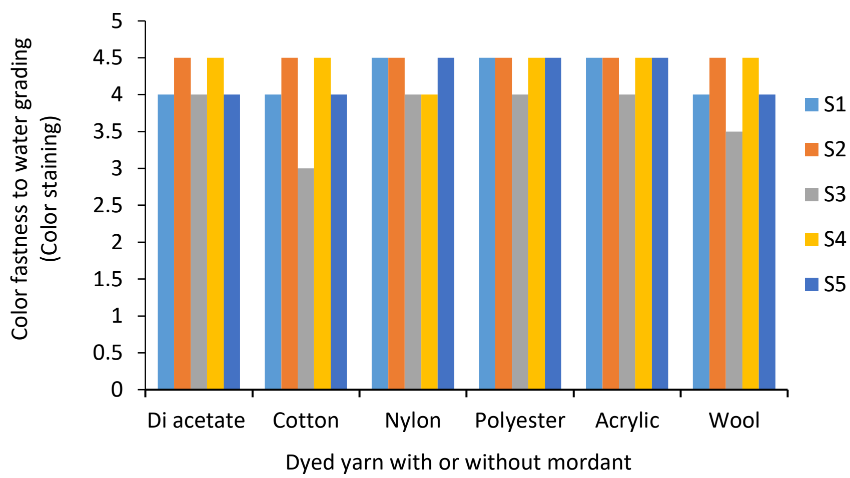


Fig. 7. Colorfastness to water (Color staining) of dyed yarn with or without mordant.

3.6. Colorfastness to rubbing

According to Figure 8, it is noticed that the dyed yarn samples provide excellent dry rubbing fastness (5) except for the yarn pre-mordanted with potassium dichromate, alum, and copper sulphate. For these three mordants dry rubbing fastness is 4-5.

In the case of wet rubbing fastness, yarn-dyed with only tea residue provides a good wet rubbing rating (4) like a dyed yarn pre-mordanted with potassium dichromate, which is prominent in Figure 9. Its rubbing fastness grading is a 0.5 grade lower than the others. Whereas, other dyed yarns yield a 4-5 rating as their depth of color is low, and that is why little color has degraded in the former case, but it is acceptable.

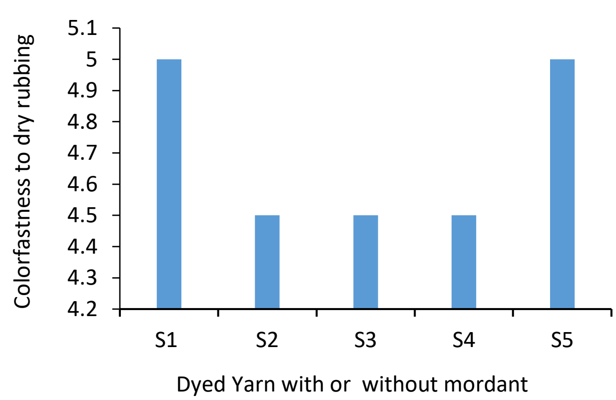


Fig. 8. Colorfastness to dry rubbing fastness of dyed yarn

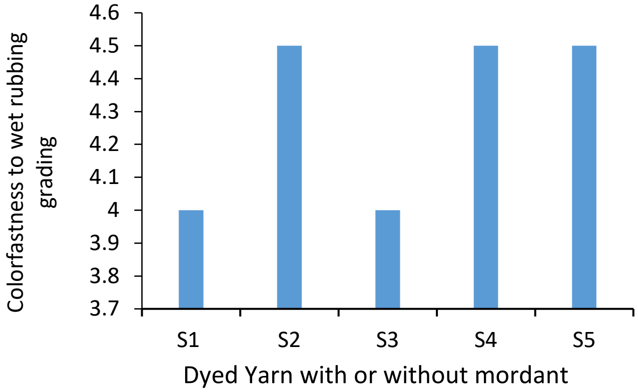


Fig. 9. Colorfastness to wet rubbing fastness of dyed yarn.

4. Conclusions

This empirical study shows the prominent dyeing effects along with their dyeing properties using tea residue. Before the invention of synthetic dyes, tea was used for the coloration of fabric. But the application of tea residue on yarn, especially for blended yarn, is a novel work. The visual and spectrophotometric results of this eco-friendly dyeing approach reveal that wool/acrylic blended yarn that is dyed with tea residue gives better color (blackish and reddish-brown) when mordanting agents and pre-mordanting with potassium dichromate are not used in the dyeing process as they exhibit a color strength value of 29.95 and 33.64. On the other hand, the colorfastness properties of different dyed yarn show moderate to good grading range (4-4.5), but in respect to all colorfastness properties, wool/acrylic yarn yields better performance when dyed without mordant or pre-mordanted with potassium dichromate.

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