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Dyeing of Bamboo with Tea as a natural Dye

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Abstract

Dyeing of bamboo fabric with green tea as a natural colorant had been investigated. The dyeing process was carried out (with and without mordanting) using pre-extracted dye stock employing either 100% water or solvent: water (1:9) mixture as the extraction medium. Three different qualities of tea leaves were used as source of colour extraction. The dyeing properties on bamboo fabric had been evaluated. Dye exhaustion, colour depth in terms of K/S, washing fastness, light fastness, etc were compared for dyeing performed at 90°C for 1hour using four extracted dye stocks on pre-mordanted and unmordanted samples.

Keywords: Bamboo, tea leaves, fastness properties, solvents.

Introduction

Textile materials are coloured for value addition, looks and fulfilling the desires of the customers. Anciently, this purpose of colouring textile was initiated using natural sources, until synthetic dyes were invented. Almost all the synthetic dyes being synthesized from petrochemical sources through hazardous chemical processes pose threat to the environment. However, worldwide environment protection and safety renewed the interest of the people on natural products like natural fibres and natural dyes[1].

For successful commercial application of natural dyes for any particular fibres, the appropriate and standardized techniques of dyeing for that particular fibre dye system need to be adopted. Relevant scientific studies and optimization of dyeing process variables, dyeing kinetics study and test of compatibility of selective natural dyes are very important[2].

Tea is a mixture of variously processed leaves of an evergreen shrub, *Camellia sinensis*, which is the most popular non-alcoholic beverage in the world. Flavonoids, flavonols and phenolic acids make up approximately 30% of dried *Camellia Sinensis* by weight. Most of the polyphenols present are flavonols commonly known as catechins, with epicatechin and its derivatives being the most predominant forms. The gallic acid ester epigallocatechin gallate (EGCG) is present in the highest concentration, making up over 61% of the epicatechin derivatives included in the green tea leaves[3]. Other green tea polyphenols include flavonoids, and their glycosides, depsides such as chlorogenic acid and coumarylquinic acid, and a phenolic acid unique to tea, theogallin. Caffeine makes up an additional 3%, and there are trace amounts of the methylxanthines theophylline and theobromine, and an amino acid unique to tea, theanin[4].

Bamboo is a naturally occurring composite material as it consists of cellulose fibres embedded in a lignin matrix. It grows abundantly in most of the tropical countries. Cellulose fibers are aligned along the length of the bamboo, providing maximum tensile strength and rigidity in that direction. It is an environmentally friendly product[5]. Through a process of hydrolysis-alkalization and multi-phase bleaching, starchy pulp is refined from Bamboo. Chemical fibre factories then process it into bamboo fibers. Repeated technological analysis has proved that this kind of fiber has thinness and whiteness close to finely bleached viscose and has a strong durability, stability and tenacity[6]. Some work on the application of tea on wool, silk[7], jute and cotton[8] are available in the literature. Applications of heena extracts on polyester[9] and tea on wool[10] using solvent as dyeing medium are also reported in the literature.

In the present work, natural tea was used to dye bamboo fabric. The colour of the tea leaves was extracted using four different extraction mediums viz. 100% water, water: acetone (9: 1 v/v), water: methanol (9:1 v/v) and water: acetonitrile (9:1 v/v). Green tea plants[11] are classified as *Camellia sinensis*. The different classes of compounds found in green tea include amino acids, catechin, caffeine, carbohydrates, carotenoids, chlorophyll, lipids, minerals, nucleotides, organic acids, saponins, polyphenols, unsaponifiable and volatile compounds[12]. The dyeing was carried out with the dye extracted from three different qualities of tea leaves using four different solvents. Dye exhaustion, colour depth in terms of K/S, washing fastness, light fastness, etc were compared for dyeing carried out using pre-extracted dye in different extraction mediums. The effect of mordanting in such dyeing was also investigated and compared.

Material and Methods

Tea leaves of three different qualities viz., Hyson (Silighuri), Kawa (Assam) and IHBT (Palampur) were collected from M/S Sethi Tea Trading Co. Amritsar. The quantitative estimation/analysis of the flavanols and polyphenols contents were not performed. Plain weave bamboo fabric (EPI: - 168, PPI: - 92, GSM: - 424 gm/m^2) was used in this study.

Extraction of dye from tea leaves: 2 gram of tea leaves was weighed. The dye was extracted in four different solvents viz. water, acetone, acetonitrile and methanol by boiling the leaves in 100ml solvent for 1 hour. Each solution was then filtered to remove the residual leaves. The filtrate was concentrated by boiling until the volume left was one fourth. This solution was again filtered so as to remove any suspended particle.

Dyeing of bamboo: Dyeing was performed using two different ways viz. (a) Dyeing of pre-mordanted bamboo fabric (b) Dyeing of bamboo fabric without mordanting.

Mordanting: Pre-mordanting treatment was conducted using copper sulphate. Bamboo fabric samples were pre-mordanted by treating it with 5.0% (owf) copper sulphate at 40 ^oC for 30 minutes with a material to liquor ratio of 1:30. After mordanting the samples were rinsed in cold water to remove the excess of mordant and used for dyeing as described in the following section.

Dyeing: Dyeing of the pre-mordanted samples was performed for 1 h at 90 ^oC in an open bath beaker dyeing machine at 30:1 liquor to material ratio. The dyed samples were rinsed in cold water and dried in open air.

Procedure for dyeing of Bamboo: 5gm sample of bamboo fabric was dyed with the extracted dye liquor. The dyeing was performed as per the condition given in table 1 and the temperature profile shown in figure 1.

Table-1
Conditions for dyeing of bamboo with tea

Parameters	Conditions
Temperature	90^oC
Time	60 minutes
pH	Neutral
MLR	1:30

Colour measurement: The K/S values of the dyed samples were measured (D_{65} illuminant, 10^o observer) using spectra flash 600 spectrophotometer interphased with computer colour matching system.

Washing fastness: Colour fastness to washing was evaluated using standard ISO 105:CO3 test[13]. ECE reference detergent and steel balls were employed during washing.

Light fastness: Light fastness was determined using ISO: 105 B02: 2000 test[13] using xenon arc lamp and blue wool reference standards.

Determination of exhaustion: The dye exhaustion % was calculated using following equation.

$$E = \frac{A0 - A1}{A0} \times 100 \quad (1)$$

Where A_0 = absorbance of dye liquor before dyeing, A_1 = absorbance of dye liquor after dyeing.

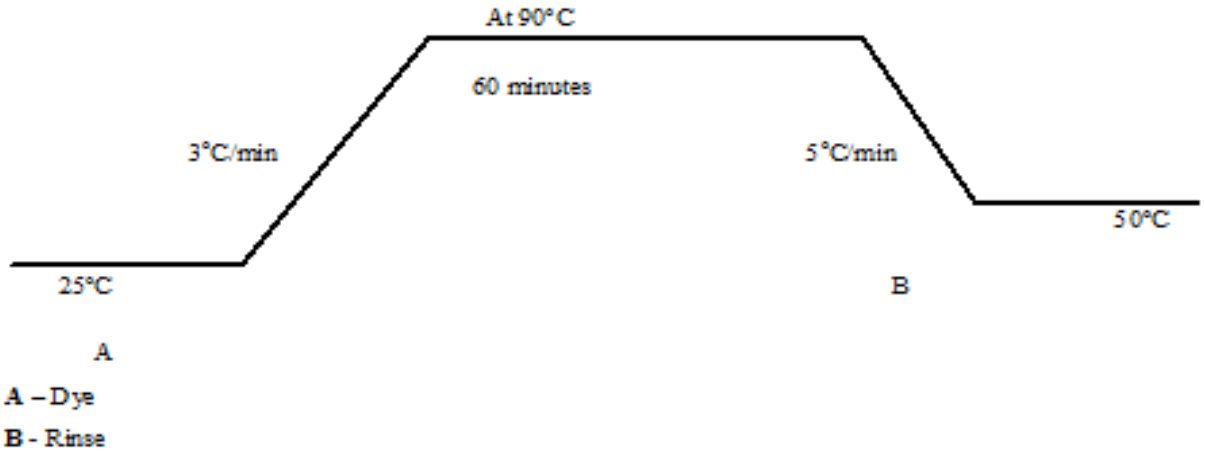


Figure-1
Dyeing cycle

Results and Discussion

The various conditions used in the dyeing of bamboo fabric samples and their codes are given in table 2. For samples 1, 5 and 9, aqueous extracts of Kawa, Hyson and IHBT tea were used. From table 3 and 4, it is clear that the exhaustions were satisfactory for all the three tea extracts used viz. Kawa, Hyson and IHBT for dyeing of bamboo. To explore the chances of better colour extraction beside 100% water the three other extraction systems viz. water: acetone (9: 1 v/v), water: methanol (9:1 v/v) and water: acetonitrile (9:1 v/v) were tried. Among the four extraction systems, water**:** acetone system produces highest colour uptake on bamboo. Among the three types of tea extracts used both Hyson and IHBT produced higher colour yield compared to Kawa for the identical dyeing conditions. The pre-mordanting treatment enhanced the dye uptake for all the samples.

Significant increase in the brightness of the dyed samples was observed in case of aqueous extracted dye stock. This comparison eliminates the requirement of solvent pre-extraction of tea leaves and motivates us to use directly the aqueous extract of tea which also reduces the cost of dyeing. The shades as presented in table 3 ranged from medium brown to dark brown. The resulting wash fastness (table 5) of the dyed samples was good to excellent in all the cases. The colour staining rating has been observed very good (4-5) in all the dyeing trails. Among the three qualities of tea, the light fastness of Kawa was found to be best which was further improved after mordanting in case of Hyson and IHBT due to the formation of coordination complexes of the dye with the mordants.

Conclusion

This study demonstrated that tea can be used as a colorant for dyeing of bamboo using aqueous extraction of tea leaves. Among the various organic solvent extraction methods used, water-acetone extraction system was found to be the best one. But pure aqueous system was also found to be equally satisfactory so far as dye exhaustion and colour yields are concerned. The dyed samples were of light brown to dark brown shades and exhibited acceptable fastness properties. It was found that Hyson and IHBT tea generated maximum colour depth among the three varieties of tea used. Kawa quality was found to develop better light fastness on bamboo.

Table-2
Various extraction mediums used for colour extraction

S. No.	Code	Colour Extraction medium used
1	AB1	Dyeing of Bamboo with Kawa tea extract using water as extraction medium
2	AB2	Dyeing of Bamboo with Kawa tea extract using mixture of water: acetone (9:1 v/v) as extraction medium
3	AB3	Dyeing of Bamboo with Kawa tea extract using mixture of water: acetonitrile (9:1 v/v) as extraction medium
4	AB4	Dyeing of Bamboo with Kawa tea extract using mixture of water: methanol (9:1 v/v) as extraction medium
5	BB1	Dyeing of Bamboo with Hyson tea extract using water as extraction medium
6	BB2	Dyeing of Bamboo with Hyson tea extract using mixture of water: acetone (9:1 v/v) as extraction medium
7	BB3	Dyeing of Bamboo with Hyson tea extract using mixture of water: acetonitrile (9:1 v/v) as extraction medium
8	BB4	Dyeing of Bamboo Hyson tea extract using mixture of water: methanol (9:1 v/v) as extraction medium
9	CB1	Dyeing of Bamboo with IHBT tea extract using water as extraction medium
10	CB2	Dyeing of Bamboo with IHBT tea extract using mixture of water: acetone (9:1 v/v) as extraction medium
11	CB3	Dyeing of Bamboo with IHBT tea extract using mixture of water: acetonitrile (9:1 v/v) as extraction medium
12	CB4	Dyeing of Bamboo with IHBT tea extract using mixture of water: methanol (9:1 v/v) as extraction medium

Mordanted samples are prefixed with M before the sample code. (Sample No.s 13-24)

Table-3
Photographs of Bamboo fabric samples dyed with Tea using mordant and without mordant

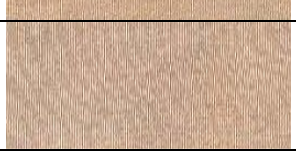
Sr. No.	Sample Codes	Samples without mordanting	Sr. No.	Sample Codes	Samples with mordanting
1.	AB1		13.	MAB1	
2.	AB2		14.	MAB2	
3.	AB3		15.	MAB3	
4.	AB4		16.	MAB4	
5.	BB1		17.	MBB1	
6.	BB2		18.	MBB2	
7.	BB3		19.	MBB3	
8.	BB4		20.	MBB4	
9.	CB1		21.	MCB1	
10.	CB2		22.	MCB2	
11.	CB3		23.	MCB3	
12.	CB4		24.	MCB4	

Table-4
Exhaustion and colour yield (K/S) of bamboo fabric samples dyed with tea colour extracted using different solvent systems

Sample Code	K/S	Exhaustion (%)	Sample Code	K/S	Exhaustion (%)
MAB1	0.55	63.2	MAB1	1.53	70.1
MAB2	0.659	66.0	MAB2	1.66	71.3
MAB3	0.773	63.8	MAB3	1.53	72.1
MAB4	0.8106	65.2	MAB4	1.37	75.8
MBB1	1.18	66.8	MBB1	2.45	72.1
MBB2	1.136	67.3	MBB2	1.66	70.2
MBB3	1.039	63.7	MBB3	1.52	72.8
MBB4	0.812	65.2	MBB4	1.20	75.6
MCB1	0.83	64.8	MCB1	2.91	74.7
MCB2	1.039	69.1	MCB2	1.63	72.6
MCB3	1.317	66.6	MCB3	2.09	74.5
MCB4	1.212	66.2	MCB4	1.90	75.1

Table-5
Fastness properties of dyed samples

Sample Code	Staining on different fibres						Light Fastness Rating
	Secondary Acetate	Cotton	Polyamide	PET	PAN	Wool	
AB1	4/5	4/5	4/5	4/5	4/5	3/4	4/5
AB2	4/5	4/5	4/5	4/5	4/5	4/5	4/5
AB3	4/5	4/5	4/5	4/5	4/5	4	4/5
AB4	4/5	4/5	4/5	4/5	4/5	4	4/5
BB1	4/5	4/5	4/5	4/5	4/5	4	3/4
BB2	4/5	4/5	4/5	4/5	4/5	4/5	3
BB3	4/5	4/5	4/5	4/5	4/5	4	3
BB4	4/5	4/5	4/5	4/5	4/5	4	3
CB1	4/5	4/5	4/5	4/5	4/5	4/5	3
CB2	4/5	4/5	4/5	4/5	4/5	4/5	3/4
CB3	4/5	4/5	4/5	4/5	4/5	4/5	3/4
CB4	4/5	4/5	4/5	4/5	4/5	4/5	3/4
MAB1	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MAB2	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MAB3	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MAB4	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MBB1	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MBB2	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MBB3	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MBB4	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MCB1	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MCB2	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MCB3	4/5	4/5	4/5	4/5	4/5	4/5	4/5
MCB4	4/5	4/5	4/5	4/5	4/5	4/5	4/5

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