

Original Research Article

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Colouring Cotton Fabric with Waste Banana Petaloids

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ABSTRACT

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Natural dyes are sustainable and renewable. This can provide employment to agricultural growers and indigenous peoples and will lead to utilization of wastes. They provide beautiful colour in ecological home fashions for environmentally concerned consumers. In present investigation cotton fabric was dyed with banana petaloids in the form of fresh flowers using pseudo stem sap, alum and tealeaves as mordants. The evaluation of colour strength (λ max, 470), visual evaluation and colour fastness tests for mordanted and dyed samples were carried out. Dyeing along with mordanting techniques which include pre, simultaneous and post mordanting was carried out. A comparison of different methods of mordanting shows that colour strength for the simultaneous mordanted dyed fabric is higher than other mordanting methods. Large range of Worn white, Greenplay gray, Banana cream and Lemon blamcolours were obtained because of varying mordant combination and their ratios. The light, washing, rubbing and perspiration fastness of dyed samples were also evaluated, giving fair range of good fastness grades. Thus banana bio waste can be successfully utilized for enrichment of textiles. It is easy in application as well as safe for the environment.

Introduction

The specialists around the world are attempting to build up a cleaner innovation and ecologically supporting methods of cotton coloring for conforming to continuously requesting ecological regulation and to save water, energy and time (10). Sustainable textile coloration is possible either by using green ingredients or zero discharge of wastewater.

In this regard natural dyes are eco-friendly, safe, cheap, need no special care, uncommon

and soothing shades, wonderful and rich in tones, act as health cure, have no disposal problems, non-carcinogenic, non-allergic, non-toxic, easily biodegradable, require simple dye house to apply on matrix and mild reactions conditions are involved in their extraction and application. There are various potential sources such as plants, insects/animals, microbes, minerals and renewable bio resource products(1).

Among all other sources banana is most promising for ample availability. After citrus, banana is the second biggest created natural

product which is contributing around 16% of the aggregate world organic product generation in 129 nations around the globe. During performing research work it was presumed, in mature banana plant relative percentages of different parts assumed as 9 per cent floral, 41 per cent outer part of pseudostem, 11 per cent fruits, 6 per cent peel, 3 per cent peduncle, 14 per cent underground parts and 16 per cent leaf stalks and leaf. So it is concluded, after harvesting of banana fruit almost 89 per cent of banana plant is accounts as waste. This huge amount of banana waste has no remarkable exploitation (1).

So, aim of this work is to quantify dyeing temperature for reasonable green coloration of cotton fabric and effective exploitation of bio-resource waste of banana plant.

Materials and Methods

Materials

Textile material

Cotton fabric was collected for this experiment. The fabric was soaked overnight in luke warm detergent solution, 5 g/100 ml of water/metre to remove starch and washed, rinsed and ironed when half wet (Verma, 2012).

Dyes and Mordants

Banana flower petals were collected from horticulture department, Chandra Shekhar Azad University of Agriculture and Technology Kanpur. Mordants used for the study were, pseudostem sap (*Musa family*), alum (*Potassium aluminium sulphate*), and tea leaves (*Camelia sinensis*). Alum was broken into small pieces and grounded into fine powder form whereas tea leaves and pseudostem sap used as such.

Methods

Concentration of dye material

Dye solutions were prepared separately by boiling of 5, 15, and 25 g fresh Banana flowers of selected extraction medium (aqueous) for 60 minutes at 80°C.

Dye extraction

Banana flower was used as the raw material for dye extraction. Optimization of extraction was performed for different durations (30, 45 and 60 min) at 80°C. The extracted dye was filtered and cooled at room temperature.

Dyeing time

Dye solution of fresh banana flower with optimized concentration and extraction time was prepared. Cotton samples were dyed in this solution for 60, 90 and 120 min, respectively at 80°C.

Dyeing temperature

The optimum temperatures for dyeing were selected 60°C, 80°C and 100°C. Dyed samples were removed from the dye bath solution, rinsed in tap water, dried in shade and ironed.

Mordants and method of mordanting

Pre and post mordanting methods using 1, 3 and 5 g for alum and tea leaves and 1, 3 and 5 ml of pseudostem sap were employed and mordanting was carried out for 30 min at 80°C. In case of simultaneous mordanting and dyeing method, mordant was added during dyeing along with the dye bath. The sample were removed from the dye bath, allowed to cool, rinsed under tap water, and squeezed lightly. These were dried in shade and ironed when half wet.

Colour absorption measurement

The λ -max of the dye was determined through scanning in UV-VIS region. Absorbance was recorded after diluting the solution 5 minutes. The optical density (O.D.) of fresh banana flower, was recorded as 470 nm respectively (5).

To calculate the percentage absorption, the absorption of the dye solution at λ -max was recorded both before and after dyeing. The optical density was recorded and percent absorption was calculated by the following formulae

$$\text{Percent Absorption} = \frac{\text{O.D of the dye liquor before dyeing} - \text{O.D of the dye liquor after dyeing}}{\text{O.D. of the dye liquor before dyeing}} \times 100$$

To record the absorbance, the solution of the dye was diluted in the same way as it was diluted for recording of λ -max.

Visual evaluation

A Proforma was prepared for visual evaluation to judge the sample of different aesthetic attributes viz; lusture, evenness of dye, depth of shade and overall appearance. A panel of 10 judges was selected through random sampling from a total population of postgraduate student and staff of Department of Textiles and Clothing, College of Home Science, Chandra Shekhar Azad University of Agriculture and Technology Kanpur for visual evaluation.

Colour fastness properties

The light, washing, rubbing and perspiration fastnesses of the dyed samples were determined according to ISO 105-BO2:2002, IS: 3561:79, ISO: 9001:2008 and ISO-E04:2009 standards, respectively.

Results and Discussion

Optimization of dye concentration

Cotton fabric was dyed with different concentration of dye source (Table 1). It is observed from the table that maximum percent absorption was obtained with 25 g. When these samples were visually evaluated, the same concentration i.e. 25 g scored highest percentage of marks. On comparing all three dye concentration of fresh banana flower, it was observed that optical density increases with the increase of dye concentration and it produced a darker shade.

Extraction time

Dye was extracted for 30, 45 and 60 min (Table 1). It is evident from the table that 60 min extraction time was found to be best. Sixty minutes extraction time was also considered as optimum for *Acalypha Wilkesiana* leaves dye used for dyeing of cotton, as reported by Manimozhi and Kanakarajan (2017).

Dyeing time

Cotton samples were dyed for 60, 90 and 120 minutes. It was found that 90 min dyeing time given higher optical density and further on increasing the time it decreased (Table 1). The above result is in accordance with the results reported by Barhanpurkar *et al.*, (2015), that the pseudo stem sap as mordant with natural dye was carried out for 90 minutes at 80°C.

Dyeing temperature

Data represented in the table 1 depicts the percentage of absorption of dye applied on different temperature from 60°C to 100°C. On visual evaluation, it was found that the maximum marks were obtained by the sample

dyed on 80°C, while 100°C temperature has highest percentage of absorption.

So, on the basis of visual evaluation 80°C temperature was selected for dye instead of 100°C temperature (Table 1) because the visual evaluation was done on different criteria including lustre, evenness of dye, depth of shade and overall appearance of the colour which are considered important by consumers while selecting coloured textile materials. Since the percentage of marks obtained through visual evaluation is a subjective approach, the appearance of colour may or may not be influenced by maximum percentage of absorption.

The above result is similar to the result reported by Hasan *et al.*, (2014) that optimized dyeing temperature was 80°C for Curcumin Dye to dye cotton fabric.

Mordant concentration and mordanting methods

Different concentrations of mordants (1, 3 and 5g/100 ml of water for alum, tea leaves and 1, 3 and 5 ml for banana pseudostem sap) were used with different mordanting methods. The percentage marks of samples mordanted with different concentration is given in table 2. Data reveals that 1g concentration for alum, 5g concentration for tea leaves and 3ml concentrated for pseudostem sap were found to produce best results with fresh banana flower dye on cotton fabric samples. Besides that simultaneous dyeing and mordanting method gave the best result with tea leaves, alum and pseudostem sap.

Table.1 Results for optimization of dyeing variables

Dyeing parameters		λ-max (470 nm)			Percentage of visual evaluation
		Optical density before dyeing	Optical density after dyeing	Percent absorption	
Concentration of dye (g)	5	0.611	0.494	19.14	42
	15	0.627	0.475	24.24	58
	25	1.155	0.849	26.49*	78.5*
Extraction time (min)	30	0.975	0.740	24.10	44
	45	1.638	1.208	26.25	52
	60	0.914	0.640	29.97*	68*
Dyeing time (min)	60	1.377	1.017	26.14	47.5
	90	1.397	1.007	27.91*	77.5*
	120	1.553	1.125	27.55	67
Dyeing temperature (°C)	60	1.215	0.927	23.70	55.5
	80	2.976	2.227	25.16	79*
	100	3.541	2.523	28.74*	64

*maximum percentage absorption and percentage of visual assessment

Table.2 Results for optimization of dye concentration and different mordanting methods

Mordant	Concentration of dye		Method of mordanting	
	Variables	Percentage of visual evaluation	Method	Percentage of visual evaluation
Alum (g)	1	81.5*	Pre	68.5
	3	73	Sim	88.5*
	5	59	Post	66
Tea leaves (g)	1	58	Pre	70
	3	72	Sim	94*
	5	73.5*	Post	64.5
Pseudostem sap (ml)	1	69	Pre	53
	3	73*	Sim	74*
	5	58	Post	54

Pre: pre-mordanting; Sim: simultaneous mordanting and dyeing and post: post mordanting

*Selected concentration and mordanting method

Table.3 Results of colours obtained by using various mordants and mordanting methods

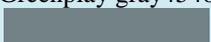
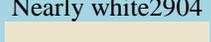
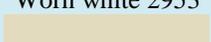
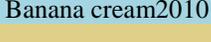
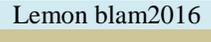
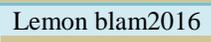
Dye source	Mordants	Methods of Mordanting	Shade of colour
Fresh Flower of Banana	Alum	I	Worn white 2953 
		II	Greenplay gray4546 
		III	Nearly white2904 
	Tea leaves	I	Worn white 2953 
		II	Banana cream2010 
		III	Lemon blam2016 
	Pseudostem	I	Lemon blam2016 
		II	Lemon blam2016 
		III	Worn white2953 
Blank			White 

Table.4 Fastness properties of dyed samples

S. No.	Mordant	Method	Light fastness	Wash fastness		Perspiration fastness				Rubbing fastness			
				CC	CS	Acidic		Alkali		Dry		Wet	
						CC	CS	CC	CS	CC	CS	CC	CS
Control			3	4	4	4	4	4	4-5	5	5	5	5
1	Tea leaves	Pre	3-4	4	4	5	4-5	5	4-5	5	5	5	4-5
		Sim	3-4	4	4-5	4-5	4-5	5	4-5	5	5	4-5	4-5
		Post	3	4	4-5	5	5	5	5	5	5	5	4-5
2	Alum	Pre	3	4	4	4-5	4-5	5	5	5	5	5	5
		Sim	3	4	4-5	4-5	4-5	5	4-5	5	5	4-5	4-5
		Post	3	4	4-5	5	5	5	5	5	5	5	5
3	Pseudo stem sap	Pre	3	4	4	5	4-5	5	4-5	5	5	5	5
		Sim	3-4	4	4	4-5	4-5	5	4-5	5	5	5	4-5
		Post	4	4	4	5	4-5	5	4-5	5	5	5	4-5

Pre: pre-mordanting; Sim: simultaneous mordanting and dyeing and post: post mordanting. CC: colour change and CS: colour staining

Colour obtained on cotton

Various colours were obtained on cotton when it was dyed with different dye sources. The colours obtained on cotton with different mordant and mordanting methods are shown in table 3. Data reveals that blank samples dyed with fresh banana flowers. Alum (method 1) showed worn white shade with cotton, (method 2) showed greenplaygray with cotton whereas (method 3) showed nearly white shade with cotton sample. Banana worn white shades with cotton (method 1), banana cream with cotton (method 2) and lemon blam with cotton (method 3) were produced by tea leaves. Similarly lemon balm (method 1 & 2) and worn white shade were produced by pseudostem sap.

Colour fastness

The colour fastness properties of all the dyed samples were found to be satisfactory. The fastness properties of cotton fabric dyed with the flower extract are presented in table 4. It is shown from the data that in case of fresh banana dye, use of natural mordants exhibited better washing, light, perspiration & light

fastness. It was also found that the post mordanting method gave the best result with most of the mordants.

It is concluded that the dye extracted from waste banana fresh flowers can be utilized to produce soft, soothing and earthen colours on cotton fabric. Infact its unused pseudostem sap can be successfully used for mordanting of the cotton fabric to obtain varying shades. Banana petaloid dye gave better fastness properties. The use of different mordants proved the effectiveness of the dye fixation as seen from the fastness results. The mordants used in the present study are environment-friendly in nature and hence will not lead to pollution problems that are usually caused by the use of heavy metals.

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