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Silk Coloration with Banana Petaloid: Optimization of Dyeing Variables

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ABSTRACT

Environment pollution is a global concern, the world is slowly realizing the damaging effects of several chemicals that are synthesized by men in laboratory. Green house effect, ozone layer depreciation, water pollution and improper waste disposal have become important issues. One of the most pressing issues today is the lack of fresh drinking water, and as one of the most polluting industries, textiles – and especially the dyeing of textiles – is responsible for many instances of pollution making fresh water undrinkable. Thus, a study was conducted to explore eco natural dye by banana flower petaloid. This study is to optimize the concentration of dye material, extraction time, dyeing time and dyeing temperature with concentration of natural mordants and mordanting methods for sustainable colouration of silk fabric employing banana waste. Best effect of optimized variables variation was observed on colour strength (λ max) and per cent marks obtained by panel of judges. The dye fiber bonding stability was accessed via colour fastness of light, washing, rubbing and perspiration. Except light fastness property almost all type of colour fastness value ranges between 3-4. Best result of λ max value was recorded at 25 g (0.817 nm), 60 min (0.693 nm) dye extraction, 90 min (0.932 nm) dyeing time and 80ºC (2.191 nm) dyeing temperature. This reports prognosis an environmental begins approach for colouration of silk fabric by deploying of banana petals waste.

Key words: Eco-friendly Colouration, Banana Petaloid Waste Exploitation, Natural Mordants, Colour Levelness and Colour Fastness Properties

1. INTRODUCTON

Now a days, fortunately there is increasing awareness among people towards natural dyes and dye yielding plants. Due to their nontoxic properties, less side effects, more medicinal values, natural dye used in day to day food products and in the pharmaceutical industry [1]. Increased environmental awareness and health hazards associated with the use of synthetic dyes which have led to the revival of natural dyes. Natural dyes are eco- friendly and promote green revolution. They are less toxic and less polluting. It is the need of the day to exploit the forest wealth which can provide us with the significant sources of imparting beautiful dyes [2]. Use of natural dyes on textile material is now being popularized globally by continuous efforts of the nature lovers. As a result, renewable resources are now being reinvestigated as the alternative raw materials. Natural dyes exhibit better biodegradability and are more environment friendly alternative to synthetic dyes [3][4][5].

Among numerous natural dye, banana is promising sustainable agricultural bio waste dye source. The ashes of banana leaves, bark and fruit rind have been reported to be in use of dyeing of textile. The cell sap of banana contains a considerable amount of tannin, which stains the cloth in almost dark black colour. The stain on the cloth is fairly permanent and very difficult to wash out [6]. During performing research work it was presumed, in mature banana plant relative percentages of different parts assumed as 9% floral stems, 41% outer part of pseudo-stem, 11% fruit, 6% peel, 3% peduncle, 14% underground parts and 16 % leaf and stalks. So it concluded, after harvesting banana fruits almost 89% of banana plant is accounts as waste. The huge amount of banana waste has no remarkable exploitation so far.

So, the aim of this work is to extract a natural dye from banana petaloid and dyed silk fabric with this dye by using three different mordants and three different mordanting methods in order to get various shades. The washing, light, rubbing and perspiration fastness of the final dyed sample had also been assessed.

2. EXPERIMENTAL

2.1 Materials

2.1.1 Textile Material

Degummed silk fabric was collected for this experiment. A detergent solution containing 0.5 ml of mild detergent (genteel) per 100 ml of water was prepared and heated at 90°C and silk was dipped into this solution and stirred gently for 2 minutes [7]. The fabric was then washed and dried at room temperature.

2.1.2 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, Alum *(potassium aluminium sulphate),* and Tea leaves. Alum and tea leaves were purchased from the local market of Kanpur. Alum was broken into small pieces and grounded into fine powder form whereas tea leaves and pseudostem sap used as such.

2.2 Methods

2.2.1 Concentration of dye material

Dye solution 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.

2.2.2 Dye extraction time

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

2.2.3 Dyeing time

Dye solution of banana flower with optimized concentration and extraction time was prepared. Silk sample was dyed in this solution for 60, 90 and 120 min, respectively at 80ºC.

2.2.4 Dyeing temperature

The optimum temperature for dyeing was 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.

2.2.5 Mordants and method of mordanting

Pre and post mordanting methods using 1, 3 and 5 g for alum and tea leaves both and 1, 3 and 5 ml for pseudostem sap were employed and mordanting was carried out for 30 min at 80ºC. 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 times. The optical density (O.D.) of fresh banana flower, was recorded as 470 nm respectively [8].

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 formula

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

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 dyed sample. The dyed samples were adjudged for 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 teaching faculty 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.

3. RESULTS AND DISSCUSSION

3.1 Optimization of dye concentration

Silk 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 produce a darker shade.

3.2 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 optimum for Acalypha Wilkesiana leaves dye used for dyeing of cotton and silk, as reported by **Manimozhi et.al.(2017)**.

3.3 Dyeing time

Silk 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 temprature.

3.4 Dyeing temperature

Data represented in the table depicts the percentage of absorption of dye applied on different temperature from 60 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.

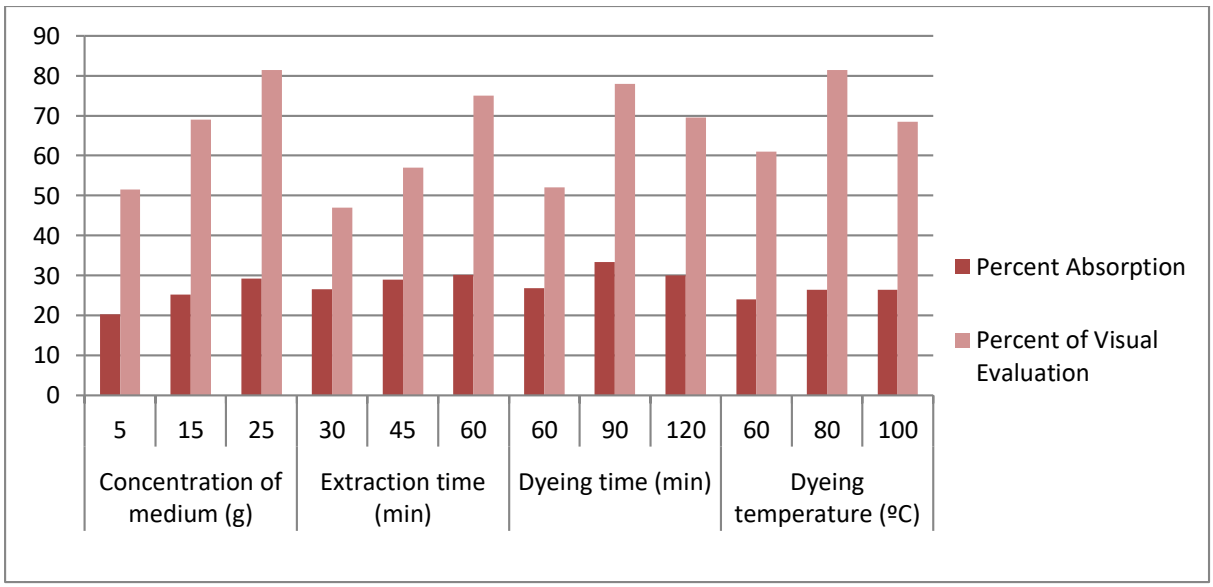
So, on the basis of visual evaluation 80°C temperature was selected for dye instead of 100°C temperature (table 1) because the visual evaluation was done on different criteria including lustre, evenness of dye, depth of shade and overall appearance of the colour which are considered more important by 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.

Similar results were reported by **Hasan et.al. (2014)** for dyeing of cotton and silk by Curcumin Dye at 80°C dyeing temperature.

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 medium (g)	5	0.611	0.487	20.29	51.5
	15	0.627	0.469	25.19	69
	25	1.155	0.817	29.26*	81.5*
Extraction time (min)	30	0.975	0.716	26.56	47
	45	1.638	1.164	28.93	57
	60	0.914	0.693	30.08*	75*
Dyeing time (min)	60	1.377	1.008	26.79	52
	90	1.397	0.932	33.28*	78*
	120	1.553	1.088	29.94	69.5
Dyeing temperature (ºC)	60	1.215	0.923	24.03	61
	80	2.976	2.191	26.37	81.5*
	100	3.541	2.514	26.46*	68.5

*maximum percentage absorption and percentage of visual assessment



3.5 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 for different mordanting methods. The percentage marks of samples mordanted with different concentration is given in table 2.

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

Mordant	Concentration of mordants		Method of mordanting	
	Variables	Percentage marks of visual evaluation	Method	Percentage marks of visual evaluation
Alum (g)	1	85*	Pre	62
	3	73	Sim	94*
	5	61.5	Post	78
Tea leaves (g)	1	67	Pre	72.5
	3	69	Sim	80*
	5	79*	Post	63
Pseudostem sap (ml)	1	0971	Pre	57.5
	3	76*	Sim	73*
	5	59.5	Post	58

Pre: pre-mordanting; Sim: simultaneous mordanting and post: post mordanting
*Selected concentration and mordanting method

When natural mordant is added in the dye bath solution, their molecules migrate from dye bath solution and get absorbed by the silk sample. With the increase in the amount of natural mordant in dyeing process from 1 to 5 g for alum and tea leaves whereas in the case of pseudostem sap 1 to 5 ml, the shade of dye varies at larger scale.

Table 2 shows that in case of concentration of mordanting agents 1 g alum, 5 g tea leaves and 3 ml pseudostem sap gives best shades on silk fabric sample because these samples revealed maximum percentage of marks, hence these concentrations were optimized for silk dyeing. In the case of mordanting methods, simultaneous mordanting method was found best for all mordants viz; alum, tea leaves and pseudostem sap. All samples dyed with simultaneous dyeing and mordanting method revealed maximum percentage of marks by judges hence this method was optimized.

3.6 Colour obtained on silk

Various colours were obtained on silk when it was dyed with fresh banana flower waste. The colours obtained on silk with different mordants and mordanting methods are shown in table 3.

Blank sample of silk dyed with fresh banana flower reveals light magenta colour while after mordanting with alum produced silent green 4565 with pre mordanting, jet gray 2873 with simultaneous mordanting and nearly white 2904 reveals with post mordanting methods. Table 3 also shows that with the different mordanting methods with tea leaves give lemon blam 2016 in case of pre mordanting and gold dust 2699 obtained by both simultaneous and post mordanting methods.

Further in the same series, in reference of pseudostem sap produce lemon balm 2016 with pre and simultaneous mordanting methods whereas post mordanting method reveals worn white 2953 color.

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	Silent green 4565
		II	Jet gray 2873
		III	Nearly white 2904
	Tea leaves	I	Lemon blam 2016
		II	Gold dust 2699
		III	Gold dust 2699
	Pseudostem	I	Lemon blam 2016
		II	Lemon blam 2016
		III	Worn white 2953
Blank			**Light magenta**

3.7 Colour fastness

The colour fastness properties of all the dyed samples were found to be satisfactory. The fastness properties of silk fabric dyed with the banana flower extract are presented in table 4.

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**	**3**	**4**	**4**	**5**	**5**	**5**	**5**	**4**
1	Tea leaves	Pre	3-4	4	4	3	4-5	5	4-5	5	5	5	4-5
		Sim	3-4	4	4-5	4	4-5	5	4-5	5	5	5	4-5
		Post	3	4-5	4-5	4	5	5	5	5	5	4-5	4-5
2	Alum	Pre	3	4	4	4-5	5	5	5	5	5	5	4-5
		Sim	3-4	4	4-5	3-4	4-5	5	4-5	5	5	4-5	4-5
		Post	3	4-5	4-5	4	5	5	5	5	5	5	5
3	Pseudo stem sap	Pre	3-4	4	4	3-4	4-5	5	4-5	5	5	5	4-5
		Sim	4	4-5	4	4	4-5	5	4-5	5	5	5	4-5
		Post	4	4-5	4	4	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

4. PREPARATION OF TEXTILE ARTICLE

Name of articles	Dye used	Mordant used	Fabric	Method of mordanting	Technique used
Top	Fresh flower	Tea leaves	Silk	Simultaneous mordanting and dyeing Method	Tie and dye (marbling)
Scarf	Fresh flower	Alum	Silk	Simultaneous mordanting and dyeing Method	Tie and die (lehariya)

5. COST CALCULATION

Cost of dyeing for 1 meter silk fabric was calculated including the electricity charges, labour cost, chemical and mordants costs, as reported by **Devi et. al. 2013**.

Table 4.1 Cost calculation of top, mordanted with tea leaves

S. No.	Criteria of cost estimation	Cost/unit	Amount used	Value (Rs.)
1	Raw material (silk)	470 Rs./m	½ meter	235
2	Dyes (Fresh Banana Flower)	-	25g	10.00
3	Mordant (Tea leaves)	10 Rs./20g	5g	2.50
	Actual cost			**247.5/-**
	Overhead charges which includes labour charge, cost of miscellaneous items, etc (20 per cent)			**297/-**

Table 4.1Cost calculation of scarf mordanted with alum

S. No.	Criteria of cost estimation	Cost/unit	Amount used	Value (Rs.)
1	Raw material (silk)	470 Rs./m	1 meter	470
2	Dyes (fresh banana flower)	-	15g	10.00
3	Mordant (alum)	479 Rs./500g	3g	1.00
	Actual cost			**481/-**
	Overhead charges which includes labour charge, cost of miscellaneous items, etc (20 per cent)			**577/-**

6. Conclusion

It can be concluded that natural dyes can be used as a substitute for synthetic dyes for dyeing of silk fabric. 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 eco-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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