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Research Paper

Khakra gum –A natural source for eco-printing of silk fabric

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■ **ABSTRACT :** Present research is based on standardization of printing procedure using *Khakra gum* (gum excrete *of Butea monosperma*) as dye source for printing silk fabric with selected mordants for mordant printing. Based on the colour strength values, clarity of design, sharpness of design and level of shades two concentration per mordants were selected for optimization of printing procedure on silk fabric and to study its effects on colourfastness properties. Aqueous medium was found suitable for extraction of dye for one hour. A dye material concentration of 2% and optimum time of dyeing was found 45 minutes for *Khakra gum*. After printing the Silk fabric with selected concentration of mordants, the samples were dyed with selected concentration of dye. The dyed and printed silk samples were post treated with 5 per cent solution of different fixing agents, Treatment 1 (T_1)- Vinegar (CH_3COOH), Treatment 2 (T_2)- Alum $AlK(SO_4)_2$, Treatment 3 (T_3)- Common salt (NaCl), Treatment 4 (T_4)- Lime juice and Treatment 5 (T_5)- Sodium carbonate(Na_2CO_3) for improving colourfastness towards sunlight, washing and crocking.

■ **KEY WORDS:** Kesula, Printing, Silk , Standardization, Colourfastness

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With the increased environmental and health concern, natural dyes are gaining popularity and are in demand among an elite group of consumers in society. They are nontoxic, non-allergic to skin, non-carcinogenic, easily available and renewable (Adeel *et al.*, 2009; Pruthi *et al.*, 2008 and Onal, 1996). Natural dyes do not create environmental problems due to their bio-degradable nature (Kulkarni *et al.*, 2011). Demand of natural dyes is increasing continuously (Samanta and Agarwal, 2009) as their production and application does not require strong acids and alkalies (Bhuyan *et al.*, 2004). A systematic and scientific approach to dye extraction, standardization of dyeing and printing procedure using natural dyes will open new vistas for its commercialization. Optimization of extraction conditions is must to minimize the investment cost and to avoid shade variations in the dyed and printed textiles. The present research has been taken up with the aim of developing the spectrum of fast printed shades using khakra gum as natural dye source on silk fabric.

■ RESEARCH METHODS

Selection of dye source :

Butea monosperma commonly known as Kesula, Khakra and Palas is found in abundant on the outskirts

of forests and scattered wastelands. It is a medium sized tree with three foliate leaves and orange showy colours in racemes.The flowers of Kesula have 'butin' which is the main colouring components, in dyeing. Flowering of Kesula plant is in February to April months.

The gum portion of this plant is locally called 'Khakre Ka Gond'. It is dark marronish black in colour. It also has medicinal value and is given to the lactating mothers. Gum part of the plant was selected as natural dye source. This plant is available in plentiful in Rajasthan and produces bright and dark shades appropriate for printing Silk fabric.

Selection of mordant concentration :

Four mordants such as alum, ferrous sulphate, copper sulphate and stannous chloride were selected for mordant printing. Based on the colour strength values, clarity of design, sharpness of design and level of shades two concentration per mordants were selected for optimization of printing procedure on silk fabric.

Printing of silk fabric :

Aqueous method was suitable for extraction of dye from khakra gum. The optimum time for extraction of dye liquor from gum was 60 minutes. A dye material concentration of 2% for *Khakra gum* was selected. The optimum time of dyeing was 45 minutes for Khakra. Silk fabric was pretreated with 2% non-ionic deferent 50% so in better dye uptake. After printing the fabric with selected concentration of mordants, the samples were dyed with selected concentration of dye. These samples were finally evaluated by a panel of judges for subjective evaluation.

Evaluation of colour strength :

Colour strength (K/S value) of a dyed sample was measured at wavelength of maximum absorption of each of the colour on MS 2000 (colour eye 3100), Macbeth UV spectrophotometer. These values are computer calculated from reflectance data according to Kubelka-munk equation.

Evaluation of colour value :

Colour value of the sample was analysed on the basis of L*a*b* values using reflectance spectra through (colour eye 3100) Macbeth UV spectrophotometer. The L*value is a measure of lightness and darkness of the colour while to define the colour on a two dimensional chromatic space of green-red axis and blue-yellow axis, a* and b* values were evaluated.

Effect of after treatment on colourfastness properties :

After dyeing the samples were post treated with 5 per cent solution of different fixing agents such as- Treatment 1 (T_1)- Vinegar (CH_3COOH), Treatment 2 (T_2)- alum $AlK(SO_4)_2$, Treatment 3 (T_3)- common salt (NaCl), Treatment 4 (T_4)- lime juice and Treatment 5 (T_5)- sodium carbonate(Na_2CO_3) for improving colourfastness of natural dyes on silk. The dye extraction and treating procedures were standardized based on the procedures suggested by AICRP Home science (1997), same was used for optimization of dye material concentration. The treatments were given to the dyed and printed silk samples and evaluation of treated samples in terms of colourfastness to sunlight, washing and crocking both dry and wet before and after treatment was undertaken by following the standard procedures laid down by Bureau of Indian standard Test Series IS 768- 1956 for colour change and is 769-1956 for staining using geometric grey scale. The results were analyzed based on the colour fastness of control samples to find out the impact of the treatments.

■ RESEARCH FINDINGS AND DISCUSSION

From Table 1, it may be seen that K/S value showing colour strength of dyed samples was found more at 15 % and 20% concentration with alum mordant and declined at 5 and 10% concentrations. In case of stannous chloride the value increases upto 4 and 5 per cent. In case of ferrous sulphate was maximum at 3 per cent concentration and later it continued to decline with the decrease in mordant concentrations.

Table 1 : Optimization of mordant concentration by K/S value (Dye concentration: 2%, Time of dyeing: 60 minutes, MLR : 1:20)

Sample number	Mordant concentration (%)	L*	a*	b*	K/S	Relative ranking
Alum						
1.	5	45.68	20.21	18.90	3.48	III
2.	10	43.21	17.76	15.86	3.22	IV
3.	15	55.31	9.65	18.57	6.27	I
4.	20	46.51	15.68	14.64	4.30	II
Copper sulphate						
5.	0.5	40.47	19.23	17.090	3.15	II
6	1	52.35	11.70	16.57	5.05	I
Stannous chloride						
7.	2	54.372	12.716	18.527	5.93	III
8.	3	52.265	11.75	16.08	5.54	IV
9.	4	58.326	12.338	17.682	7.67	I
10.	5	56.69	9.97	16.464	6.80	II
Ferrous sulphate						
11.	2	36.525	18.001	16.904	1.69	I
12	3	23..358	4.842	3.084	0.94	III
13.	4	27.199	6.353	4.524	0.75	IV
14.	5	24.086	3.963	2.477	0.96	II

Subjective evaluation of after treatments :

Post treatment with (T_2) and (T_5) had contributed for improvement in depth of colour, clarity of design and sharpness with alum mordant printed samples at both the selected concentrations as shown by maximum mean score in Fig. 1. Samples post treated with vinegar, (T_1) also scored good at both mordant concentrations.

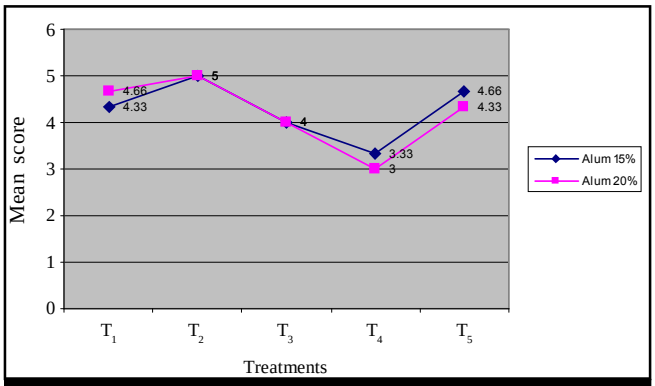

Fig. 1 : Mean score of after treated samples of alum mordant

Fig. 2 depicts the mean scores of after treated samples printed with copper sulphate mordant at selected two concentrations. It can be seen that treatment T_1, T_2 and T_3 had produced good results at lower concentration (5%) and treatment T_2, T_5 followed by T_3 and T_4 had

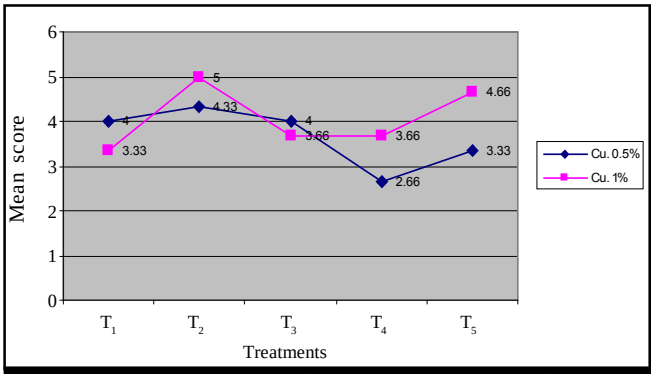

Fig. 2 : Mean score of after treated samples of copper sulphate mordant

produced good result at higher (1%) concentration.

Treatment T_3 produced best result at the both the concentration followed by T_2 and T_5 at higher concentration and T_1 and T_5 at lower concentration. Treatment T_4 at both the concentration and T_2 at lower concentration did not produce good result.

In case of stannous chloride mordant printed samples, the improvement was extremely visible in the samples treated with T_1 and T_2 followed by vinegar T_5 for both the concentrations as shown in Fig. 4. T_4 and T_3 treatment were not suitable as per the mean scores obtained.

Hence, based on the mean scores it can be

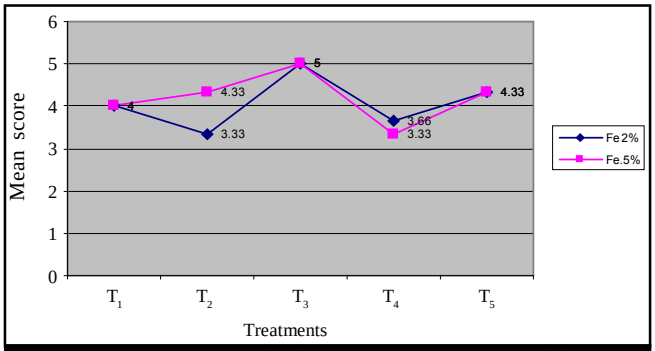

Fig. 3 : Mean score of after treated samples of ferrous sulphate mordant

suggested that in general T_2, T_1 and T_5 treatments had shown remarkable improvement as far as clarity of design, sharpness of design and level of shades are concerned with mordant printed and khakra dyed samples.

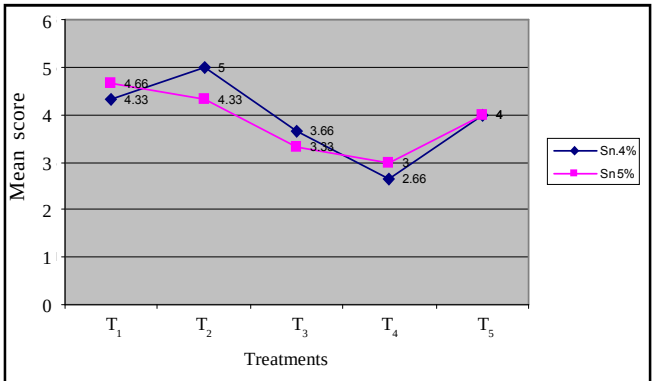

Fig. 4 : Mean score of after treated samples of stannous chloride mordant

Testing of colorfastness :

Fastness to sunlight :

The sunlight fastness data revealed that resistance to colour change on silk samples due to sunlight was improved and shades became darker with all mordant printed samples after treated with various agents.

Table 2 depicts that In alum mordant on treatments showed good to very good sunlight fastness. Treatment with T_4 showed improvement in terms of colour change due to washing at 10% of Alum mordant. In 20% of alum printed samples all the five treatments showed very good sunlight fastness. Except treatment T_1 and T_2 showed very good results at lower concentration and except T_1 treatment all the four treatments showed maximum result due to wash fastness in terms of colour change and colour staining.

Data pertaining to dry crock fastness, T_4 showed good results at lower concentration and treatment T_1 and T_4 showed good results at higher concentration (20%).

All the after treated samples showed improvement at both the concentration of alum mordanted silk samples. T_4 treatment showed very good fastness rating among all the treatments at both the concentration.

It can be seen from Table 3 that all the treatment showed very good to excellent sunlight fastness, wash fastness in terms of colour change and colour staining, dry and wet crock fastness. Treatment T_1 showed maximum fastness ratings at both the concentration.

Table 4 depicts data of Fastness evaluation of the

Table 2 : Fastness evaluation of the alum printed silk fabric dyed with *Khakra* Gum dye

Mordant concentration	Treatments	Colour obtained	Sun light CC	Wash fastness CC	Wash Fastness CS	Dry crock fastness CC	Dry crock fastness CS	Wet crock fastness CC	Wet crock fastness CS
	Control	Light brown	8	4/5	4/5	4	3	4	3/4
	T_1	Tan	7	4/5	4/5	4	3/4	5	4
	T_2	Coffee brown	Shade became darker	4/5	4/5	4/5	3	5	4/5
15%	T_3	Brown	Shade became darker	5	5	4	3	5	4
	T_4	Peach	Shade became darker	5	5	4/5	4	5	4/5
	T_5	Terracotta	Shade became darker	5	5	4	4	4/5	3/4
	Control	Peach	7	4/5	4/5	4/5	4	4/5	4
	T_1	Burnt sienna	7	4/5	4/5	4/5	4/5	5	4
	T_2	Coffee brown	Shade became darker	5	5	4/5	4	4/5	4
20%	T_3	Brown	Shade became darker	5	5	4/5	4	5	4
	T_4	Peach	Shade became darker	5	5	4/5	4/5	4/5	4
	T_5	Terracotta	Shade became darker	5	5	4/5	4	4/5	3/4

Dye concentration: 2%, Time of dyeing: 60 minutes, MLR: 1:20, Time of after treatment: 30 minutes

Table 3 : Fastness evaluation of the Copper sulphate printed fabric dyed with Khakra Gum dye

Mordant concentration	Treatments	Colour obtained	Sun light CC	Wash fastness CC	Wash Fastness CS	Dry crock fastness CC	Dry crock fastness CS	Wet crock fastness CC	Wet crock fastness CS
	Control	Honey	7	4/5	4/5	5	4	4/5	4
	T_1	Coffee brown	Shade became darker	5	5	5	4	5	4/5
0.5%	T_2	Apricot	Shade became darker	5	5	4	4/5	4	4/5
	T_3	Honey	8	5	5	4/5	3/4	4/5	4
	T_4	Terracotta	Shade became darker	4/5	4/5	5	4/5	5	4/5
	T_5	Ecru	7	4/5	4/5	5	5	4/5	4
	Control	Honey	8	4/5	4/5	4/5	4/5	5	4/5
	T_1	Brick	8	5	5	5	4/5	5	4
1%	T_2	Light brown	7	5	5	5	4/5	5	4
	T_3	Terracotta	8	5	5	5	4/5	5	4/5
	T_4	Pumpkin	Shade became darker	5	5	5	4/5	5	4
	T_5	Rust	7	4/5	4/5	5	4/5	5	4/5

Dye concentration: 2%, Time of dyeing: 60 minutes, MLR: 1:20, Time of after treatment: 30 minutes

Table 4 : Fastness evaluation of the Stannous chloride printed silk fabric dyed with Khakra Gum dye

Mordant concentration	Treatments	Colour obtained	Sun light CC	Wash fastness CC	Wash fastness CS	Dry crock fastness CC	Dry crock fastness CS	Wet crock fastness CC	Wet crock fastness CS
	Control	Pumpkin	7	4/5	4/5	4/5	4	4	3/4
	T_1	Tan	Shade became darker	5	5	4/5	4	4/5	3/4
4%	T_2	Choclate brown	Shade became darker	4/5	5	4/5	3/5	4/5	4
	T_3	Garnet	Shade became darker	5	5	5	4	4	4
	T_4	Peach brown	Shade became darker	4/5	5	4/5	4	5	4
	T_5	Walnut	Shade became darker	4/5	5	5	4	4	4
	Control	Peach	7	5	4/5	4	4	4/5	4/5
	T_1	Choclate brown	Shade became darker	5	5	4/5	4	5	4
5%	T_2	Rust	Shade became darker	5	4/5	4/5	4/5	5	4
	T_3	Honey	Shade became darker	5	5	4/5	4	5	4
	T_4	Melon	Shade became darker	5	4/5	4	4	5	4/5
	T_5	Walnut	Shade became darker	5	5	5	4/5	4/5	4/5

Dye concentration: 2%, Time of dyeing: 60 minutes, MLR: 1:20, Time of after treatment: 30 minutes

Table 5 : Fastness evaluation of the Ferrous sulphate printed silk fabric dyed with Khakra Gum dye

Mordant concentration	Treatments	Colour obtained	Sun light CC	Wash fastness CC	Wash fastness CS	Dry crock fastness CC	Dry crock fastness CS	Wet crock fastness CC	Wet crock fastness CS
	Control	Wine	7	4/5	4/5	4/5	4	5	4
	T_1	Choclate brown	8	4/5	5	5	4/5	5	4
2%	T_2	Burgundy	7	5	4/5	5	4/5	5	4
	T_3	Charcoal	8	5	4/5	5	4/5	5	4/5
	T_4	Walnut	Shade became darker	4/5	4/5	5	4/5	4/5	4
	T_5	Coffee	7	5	4/5	4/5	4/5	5	4/5
	Control	Wine	8	4/5	4	4/5	3/4	4/5	4
	T_1	Burgundy	7	4	4/5	4/5	4	5	4
5%	T_2	Smoke	Shade became darker	5	5	5	4	4/5	4/5
	T_3	Charcoal	8	5	4/5	5	4/5	5	4/5
	T_4	Walnut	Shade became darker	4/5	5	4/5	4/5	4/5	4/5
	T_5	Coffee brown	8	4/5	4/5	4/5	4	4/5	4

Dye concentration: 2%, Time of dyeing: 60 minutes, MLR: 1:20, Time of after treatment: 30 minutes

alum printed silk fabric dyed with *Khakra* gum dye. All the treatments given showed very good fastness, in case of sunlight fastness, the shades became darker on exposure to light. Fastness towards other agencies improved specially wash fastness and wet crock fastness. Treatment T_1 showed good fastness ratings at lower concentration and T_5 at higher concentration. A range of brown, rust, honey, melon, walnut were obtained as compared to peach and pumpkin shades obtained in control samples at selected concentrations.

Data in Table 5 depicts fastness results obtained by giving various after treatments. All the treated samples showed very good to excellent sunlight fastness, wash fastness in terms of colour change and colour staining, dry and wet crock fastness. Treatment T_3 showed maximum fastness ratings at both the concentration. Shades of coffee, wine, charcoal etc. were produced using selected after treatments on dyed and printed samples.

Development of value added products:

The researcher made efforts to develop some value added silk products using standardized printing procedure. Following plate shows developed short silk kurti.

Conclusion :

Findings highlights the improvement in clarity of designs, sharpness of design and level of shades due to the effect of after treatments given in all the mordant printed silk samples with vinegar (T_1), alum (T_2), common salt (T_3) treatments in all these categories at both the selected concentration with selected dye source. Further, developed Silk product printed with 2% khakra gum dye extract and after treated with 5% common salt ,Vinegar and alum exhibited excellent fastness with better dye receptivity.

Further, from the economic point of view, the cost of making One kg of printing paste using the Khakra gum dye source comes out to be Rs.120/- only, which is enough for printing 30 meters of Silk fabric. Hence it can be concluded that silk fabric can be successfully printed with optimized variables using khakra gum dye and given appropriate after treatments to achieve good results.

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