A study of colour strength of cotton printed with black cutch dye and sodium alginate gum

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ABSTRACT : Different printing paste recipes were prepared using a byproduct of Katha industry (Black cutch) as dye in three different concentrations of 30%, 40% and 50%. The total amount of water required by the thickener to make a printing paste of optimum consistency was broken down into three dye:water ratios namely 25:75, 50:50 and 75:25. Washed cotton fabric was printed using flat screen method with two uniform strokes in forward and backward direction of the screen. Varying dye concentrations and dye:water ratios in printing paste significantly affected the colour strength values of printed cotton samples. There was increase in K/S on increasing the dye:water ratio from 25:75 to 50:50 and 75:25 in printing paste for all the three dye concentrations. Highest colour strength (4.963) was observed for 30% dye concentration with 75:25 dye:water ratio in printing paste. High dye concentration of 40% in all dye: water ratios performed lower on colour strength when compared to 30% dye concentration. Thus, the total amount of dye (in terms of dye:water ratio) added in printing paste played a major role in obtaining good colour strength with sodium alginate gum.

Key words: Cutch dye, colour strength, cotton, printing, screen printing, sodium alginate

Various scientists have stipulated theories about colours and their impact on human life. A mixture of colours, their tints and shades gives a range of cool colours and warm colours, dark colours and light colours, bright colours and dull colours, pastel colours, earthy colours and so on. Every colour has a unique effect on individuals which guides and stimulates brain cells for a specific response, mood or behavior (Mehta and Zhu, 2009). Humans, since prehistoric times, have tried to extract colours from natural resources like flowers, leaves, barks, roots and fruits of various plants, minerals and insects for introducing colours to the articles and objects of their routine life. The incorporation of colours makes them attractive, interesting and appealing to human eyes (Goetz, 2008). Textile substrate had been one of the major areas of colour application.

Printing is one of the means of colouration of textile material besides dyeing and painting. There are different technologies, media and substrate presently used in the printing industry. Flatbed screen printing is one of the most popular technologies in small scale printing units besides block printing. Irrespective of advancements in textile printing technologies, styles and printing media for the industry, most of the printing of textile materials has been done in the country by cottage scale industries or small and medium scale industries using screen and block printing technique. Presently, in most cases, synthetic dyes are applied using commercially available synthetic binders or natural gums for flatbed screen printing (AICRP, 2014). Even in handicraft sector of India, which is mostly unorganized, printing is done by block printing, resist printing and screen printing using synthetic or synthesized natural dyes. The consumer, both in international and national market, is now more concerned and interested in buying textile products that cause least harm to the environment from its cradle to grave. Production and incorporation of natural dyes or extraction of dye from an industrial byproduct combined with use of natural gums could be beneficial for the manufacturers. This industry of natural, biodegradable and environment friendly textile products is projected to grow in the future owing to high consumer demand.

Thus, present work was undertaken to prepare different printing paste recipes using an industrial byproduct as a dye in different concentrations and sodium alginate as thickener. By this, an attempt was made to know the compatibility of dye in the printing paste and the potential of Black cutch for printing textiles at large.

MATERIALS AND METHODS

1. *Fabric*: Bleached, mercerized 100 percent cotton fabric in plain weave manufactured by Bombay Textile Mills, Erode, Periyar, Tamil Nadu was purchased from Pantnagar, U S Nagar, Uttarakhand. The properties of selected fabric are given in Table 1.
2. *Dye*: The byproduct of Katha industry, Black cutch, in the form of 7 square inch brick was procured from Kattha industry, Rampur Road, Haldwani, Uttarakhand.
3. *Thickener*: Sodium alginate used in the study was procured from Molychem, Mumbai, India.
4. *Screen and squeegee*: Flat screen with a printable area of 5 square inch prepared by photosensitive emulsion on nylon mesh fixed over wooden frame was procured from a local printing unit at Nagla, Pantnagar, Uttarakhand. A 6 inch metal frame squeegee was used for printing.

Methods

1. *Preparation of fabric:* The fabric was washed with 2 g/l soap at 60°C for 30 min (Klaichoi *et al*., 2012) to remove starch and other finishes applied on cotton fabric for improving fabric handle and crease resistance. The soap used in this study was a natural soap procured from ABC Industries, Bazpur. Then the fabric was thoroughly rinsed in tap water and air dried at room temperature. The fabric was ironed before printing.
2. *Preparation of dye solutions:* Dye brick was first broken down in small pieces in a mortar and pestle. Then a fine powder was prepared in a 1000W grinder. Three dye concentrations namely 30%, 40% and 50% (Teli *et al*., 2014) were prepared by keeping them in distilled water for one hour at boiling temperature. Each of the extracted dye solution was cooled and filtered through two layers of fine muslin cloth in addition to a fine mesh strainer.
3. *Preparation of printing paste recipes:* The concentration of dye and the amount of dye & water to be used in the printing paste for obtaining optimum colour was determined by preparing three dye:water (25:75, 50:50 and 75:25) ratios. To make a paste of sodium alginate, 2 g of gum was weighed in a beaker and 14 ml of distilled water was poured in it all at once and immediately stirred swiftly with a glass rod in continuous circular and forward-backward direction to avoid lump formation. A sodium alginate paste of optimum consistency was obtained. The total amount of water required to make a printing paste was broken down into three dye:water ratios namely 25:75, 50:50 and 75:25. Thus for 14 ml water, the ratios were calculated to be 3.5:10.5 ml, 7:7 ml and 10.5:3.5 ml respectively. The sodium alginate recipe for 30 percent dye concentration and 25:75 ratio was coded as SA3025 and similarly for rest of the two ratios coding was SA3050 and SA3075 respectively. For 40 % dye concentration, the recipes were coded as SA4025, SA4050 and SA4075 while for 50% dye concentration; the coding was SA5025, SA5050 and SA5075. Thus, a total of nine recipes for three dye concentrations and three dye: water ratios were made and printing was done.
4. *Printing of samples:* Samples were printed using flat screen method with two uniform strokes in forward and backward direction of the screen
5. *Washing and Steaming:* Dried printed samples were steamed at 120°C+2°C for 20 minutes (Rekaby *et al*., 2009). Then the steamed printed samples were rinsed under tap water and dried under shade. The selection of gum paste was done on the basis of colour strength of printed samples.
6. *Testing of Colour strength:* The K/S value (Kumaresan et al., 2012) of the white and printed cotton fabrics was determined by measuring surface reflectance of the samples using a computer-aided Premier Colourscan 5100A dual spectrophotometer, using the following Kubelka Munk equation.

$$K/S = (1- R\lambda_{max})2= \alpha C_d 2R\lambda_{max}$$

where K is the coefficient of absorption; S the coefficient of scattering; C_d the concentration of the hue and $R\lambda_{max}$ the surface reflectance value of the sample at a particular wavelength, where maximum absorption occurs for a particular dye/colour component. The software was set on default for taking three readings of each area and three replicates of each sample was measured to give average K/S value of nine readings per sample at 490 nm.

7. *Hypotheses to be tested:* Statistical analysis was done on IBM SPSS Statistics version 20. Two hypotheses to be tested are given below:
   H_{01}: No change in K/S on varying amount of dye in paste

Table 1: Properties of selected cotton fabric

S.No.	Fabric Properties		Values
1.	Fabric count	Number of warp	88
		Number of weft	67
2.	Weight (GSM)		0.97g/100sqcm
3.	Thickness		0.218 mm

H_{11}: Amount of dye in printing paste changes K/S of printed samples
AND
H_{02}: No change in K/S on varying dye concentration
H_{12}: Varying dye concentration changes K/S of printed samples

RESULTS AND DISCUSSION

After steaming, washing and shade drying, the colour strength of printed samples was tested. The colour strength obtained by cotton samples printed with different printing paste recipes comprised of different dye concentrations and dye:water ratios are shown in Figure 1. There was increase in K/S on increasing the dye:water ratio from 25:75 to 50:50 and 75:25 in printing paste for all the three dye concentrations.

Highest colour strength (4.963) was observed for 30% dye concentration and 75:25 dye:water ratio in printing paste. For the 25:75 dye:water ratio, lower K/S resulted at higher dye concentrations of 40% and 50%. This may be due to better saturation of dye at 30% concentration than at 40% and 50% concentration. On comparing, individual dye concentrations in their respective dye:water ratios i.e. 30% concentration used in 25:75, 50:50 and 75:25 ratio, a gradual increase in K/S was found ranging from 1.872 to 4.963 and similarly K/S value of 1.767 increased to 2.764 for 40% dye concentration. Thus, it can be said that on increasing dye concentration as well as amount of dye in terms of dye:water ratio in the printing paste, the K/S of printed cotton samples was increased. The ANOVA (Table 2) resulted in significant values for overall model, dye:water ratio in the recipe of printing paste, dye

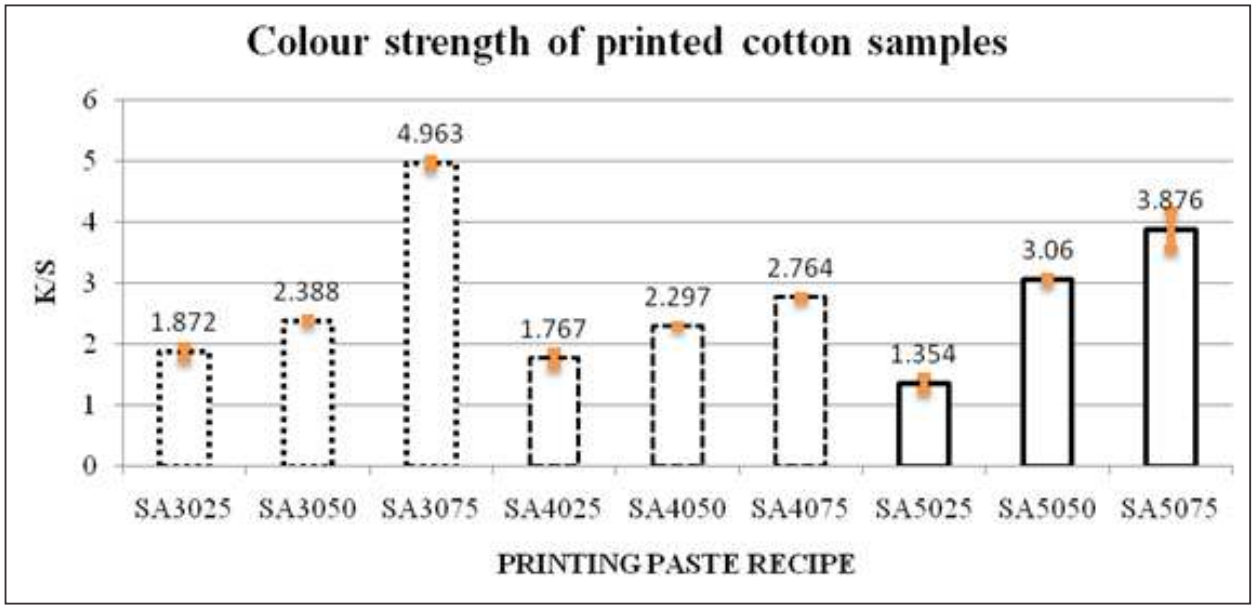

Fig. 1. Colour strength (K/S) of cotton samples for different sodium alginate printing paste recipes

Table 2: ANOVA to Test Between-Subjects Effects
Dependent Variable: K/S (Colour strength)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	22.321[a]	8	2.790	106.042	.000
Intercept	133.498	1	133.498	5073.818	.000
ratio	15.598	2	7.799	296.419	.000
conc	2.241	2	1.120	42.580	.000
ratio * conc	4.482	4	1.120	42.584	.000
Error	.237	9	.026		
Total	156.055	18			
Corrected Total	22.557	17			

a. R Squared = .990 (Adjusted R Squared = .980)
b. Alpha=0.05

concentration and interactive effect of dye:water ratio in the recipe and dye concentration which coincided with the results.

Further from the Duncan Post hoc table (Table 3), it can be seen that significant difference lies between all the three dye:water ratios i.e. 25:75, 50:50 and 75:25, thus H_{01} was rejected at 5% level of significance and it was concluded that amount of dye in terms of dye:water ratio in printing paste significantly changed the K/S of printed cotton samples.

Similarly, in Duncan Post hoc Table 4 [Table of means for groups in homogenous subsets (Dye concentration versus K/S)], significant difference lies between all the three dye concentrations and the K/S of printed cotton fabric. Thus, H_{02} was rejected at 5% level of significance and it was concluded that varying dye concentration significantly changed the K/S of printed cotton samples. Good colour strength of printed fabrics was obtained at lower dye concentration of 30% used with high dye:water ratio (75:25). This may be attributed to better fluidity of dye on the fabric at 30% dye concentration leading to better absorption and saturation. Then increasing the dye concentration to 40% reduced the fluidity of dye with the printing paste causing poor diffusion of dye molecules through the fabric. But further increase in dye concentration (50%) caused forceful adsorption on the fabric or adhesion thus results for 50% dye concentration were better than 40% dye concentration.

Table 3: DUNCAN Post hoc table of means for groups in homogenous subsets (Dye:water ratio versus K/S)
Duncan: K/S (Colour strength)

Ratio	Subset		
	1	2	3
25:75	1.6617		
50:50		2.5800	
75:25			3.9283
Sig.	1.000	1.000	1.000

Based on observed means. The error term is Mean Square (Error) = .026.
Alpha = 0.05.

Table 4: DUNCAN Post hoc table of means for groups in homogenous subsets (Dye concentration versus K/S)

Dye conc.	Subset		
(%)	1	2	3
40.00	2.2733		
50.00		2.7617	
30.00			3.1350
Sig.	1.000	1.000	1.000

Based on observed means. The error term is Mean Square (Error) = .026.
Alpha = 0.05.

On increasing the amount of dye (which is a liquid too) and reducing the water content, the swelling of thickener was also affected, thus causing thinning of printing paste making it hard to print. Thus a systematic interval was taken to prepare these recipes. All the recipes were found to be of optimum consistency appropriate for printing on fabric. This study was helpful in proving that the total amount of dye (in terms of dye:water ratio) added in printing paste played a major role in obtaining good colour strength with sodium alginate.

CONCLUSION

The study of making a printing paste recipe, the quantification of water content in terms of dye:water ratio in relation to dye concentration is a new concept. It upholds the logic of getting a good printing paste that yields concrete results and makes practical calculations in printing textile materials possible. There is no stringent process of preparing a printing paste and amount of dye to be added to the paste is also not limited. It depends on the users' choice and experience that one can choose to achieve more depth of colour by increasing the amount of dye while allowing complete swelling of thickener. It was found that varying dye concentration as well as amount of dye in terms of dye:water ratio, significantly changed the K/S of printed cotton samples. This study was successful in proving that low dye concentration used in higher amounts (high dye:water ratio) in printing paste yielded higher colour strength. But, the K/S results were not congruent with the concept that low concentration in high amount or high concentration in low amount would yield almost same colour strength. The total amount of dye (in terms of dye:water ratio) added in printing paste played a major role in obtaining good colour strength with sodium alginate as thickener. Also, it has been made possible, to quantify the amount of water and dye to be added to the printing paste to achieve a desired range of K/S from Black cutch dye and sodium alginate gum. All the recipes developed in the present study were printable on cotton fabric.

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