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Eco-Friendly Printing of Cotton Fabric using Natural Dye from *Annona Squamosa* L.

K Prathyusha [1] and I Rajitha [2]

Department of Apparel and Textiles, College of Community Science
Professor Jayashankar Telangana State Agricultural University, Hyderabad 500 035 (Telangana)

ABSTRACT

Natural dyes are the colours extracted from natural sources like roots, wood, bark, leaves, flowers, nuts, seeds, insects and mineral compounds etc. These were the only source of colour until the invention of synthetic dyes. Synthetic dyes occupied the market place within no time and are excessively used to meet the requirement of the global consumption. These dyes have negative impact on environment and cause serious health hazards. The present study tried to explore screen printing of cotton fabric with *Annonna Squamosa* L. leaf dye extract. The natural dye was extracted from leaves of custard apple through aqueous method, which was used as colouring pigment in the print paste. Four different mordants were tried in the study to acquire different hues. The printed fabrics were evaluated by measuring the fastness properties. The samples printed underwent through subjective evaluation interms of depth of colour and sharpness of print. It was concluded that distinctive shades were obtained by different mordants when mixed with same dye extract and excellent fastness properties were portrayed by the sample printed with custard apple leaf dye in combination with copper sulphate mordant.

Key Words: *Annona Squamosa,* Eco friendly prints, Cotton, Sustainable Prints, Natural dyes, Screen Prints, Mordants.

INTRODUCTION

Natural dyes are the oldest colouring agents. The art of dyeing textiles and decorating walls with colours obtained from natural sources dated back to prehistory (Siva, 2007). A revival interest in the use of natural dyes for colouring textiles has been growing now a day because of the environmental standards set by many countries due to the surge in the land, water and air pollution by the synthetic dyes (Nagia and Mohamedy, 2007). The amount of effluents resulting from synthetic dyes can be reduced by the use of natural dyes and hence can be used for colouring textiles. Due to the increased awareness of environmental protection, attention of researchers has shifted to natural dyes for dyeing textile materials (Samanta and Agarwal, 2009). The range of pallet for natural dyes is wide which can be obtained from different sources of plants and insects (Hamdy *et al,* 2021). Most natural dyes require a chemical in the form of metallic salt to create an affinity between the fibre and pigment (Janani *et al,* 2014). Natural gums are preferred for natural dyes over synthetic ones in textile printing, as these are biocompatible, cheaper and easily available (Padma and Khateeja, 2017). The sources of natural dyes are not only used for dyeing of textiles but also can be used for printing textiles (Rekaby *et al*, 2009).

Annona squamosa L. is a shrub or small tree belonging to the family *Annonaceae* of American origin. The leaves of this plant have number of chemical compounds belonging to the diverse groups including phenolics, annonaceous

Corresponding Author's Email: geetha.prathyusha@gmail.com

[1]Assistant Professor

[2]Associate Professor, Department of Knit Wear technology, National Institute of Fashion Technology, Hyderabad 500 081.

acetogenins, saponins, tannins, flavonoids, alkanoids, glycosides, alkaloids, steroids and terpenoids (Gowdhami *et al*, 2014). The presence of some of these compounds are associated to dye yielding properties in plants, like tannins in the extracts of leaf results in brown shades of colour as reported by Janani *et al* (2014). Also, various parts of this plant are traditionally known for their medicinal potential in curing diseases in many parts of the world (Bhat and Paliyath, 2016 and Zahid *et al (*2018). In the present study, dye extract from the leaves of *Annona Squamosa* L. was used to colour plain cotton woven fabric by application of four different mordents using screen printing method. The colourfastness to washing, perspiration, crocking and light were also determined.

MATERIALS AND METHODS

The study was carried out during November 2021 in Hyderabad. Cotton was preferred because of its innate characteristics like easy to dye or finish with high rate of absorbency. 100 per cent plain weave cotton fabric with 122 GSM and 200 thread count was selected and subjected to scouring with 2 g/litre of non-ionic detergent with material liquor ratio of 1:20 for 1 to 2 hr. This process helps to remove the impurities that might hinder the absorption of dye during printing process. The cotton fabric does not have natural affinity for most of the natural dyes. Hence, in traditional methods of dyeing, cotton is pre-treated with tannin (pre-treatment) and then with mordant and dyed for dye fixation as reported by Gulrajani (1999). In this study, the cotton fabric is pre-treated with natural myrobalan solution (Teli *et al,* 2014).

Leaves of *Annona squamosa* L. were procured from surroundings of Prof. Jayshankar Telangana State Agricultural university campus of Hyderabad and were processed to be used for preparation of dye. Aqueous method of extraction was followed in this study. The leaves were shade dried and were weighed, soaked overnight and boiled for 45 minutes in water with material to liquor ratio of 1:10 at 80^0C. Then the extract was filtered and condensed to 40% (w/w) aqueous extract, which was further used for printing.

Cassia tora (*Cassia obstusifolia* L.) is an annual weed, having natural gelling property with a starch content of 30-40 per cent, which results in high viscosity. Cassia flour was used in the preparation of binding agent with material liquor ratio of 1:20. Different types of mordents deliver distinct colours for the same dye. For this study alum, copper sulphate, stannous chloride and ferrous sulphate are selected as mordents. Print paste was prepared by adding dye to gum in 4:3 ratio to which mordents were added according to the weight of the print paste. Myrobalan pre-treated cotton fabric was used for printing. Screen printing method was employed for impregnating print paste on to pre-treated cotton fabric.

After Treatment of Samples Printed

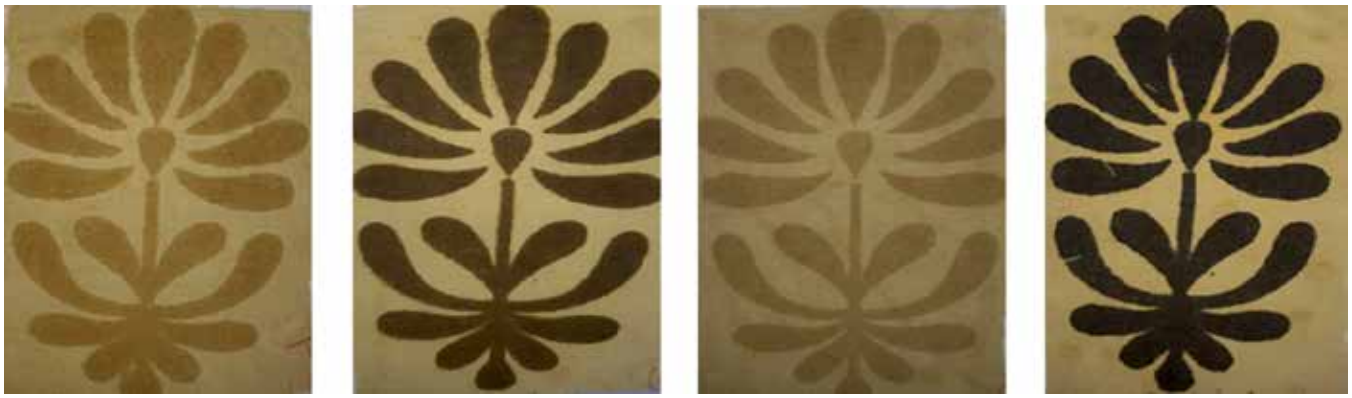
The screen printed samples were shade dried followed by steaming in autoclave for 1 hr which helps in adhering of the dye deep into the fibre surface. Steamed samples were treated with 20 per cent sodium chloride for 30 minutes followed by rinsing with 2g/l neutral soap solution which will help to remove the excess dye lingered on the surface of the printed samples.

Durability Performance- Washing, Sunlight, Rubbing and Perspiration

The assessment of after treated printed samples was done by using the standard testing procedures given by the Bureau of Indian Standard Test Series IS 768-1976 and IS 769-1956 for colour change and colour staining. Wash fastness is measured by launder-o-meter (IS: 3361-1979), sunlight fastness is tested by sunlight cabinet (IS: 686-1985), Rub Fastness is tested with crock metre(IS: 766-1956), and fastness to perspiration is tested with Perspirometer (IS: 971-1956).

Subjective Evaluation of Printed Samples

The samples printed were subjected to evaluation by 30 members who were experts in textile and apparel designing field. The evaluation



Alum | Copper Sulphate | Stannous Chloride | Ferrous Sulphate

Figure 1.0 Shades obtained by custard apple leaf extract in combination of different mordants.

was carried in terms of depth of the colour and sharpness of prints.

RESULTS AND DISCUSSION

This study aimed to showcase the use of custard apple leaf extract in screen printing of cotton fabric. During printing, it was observed that different shades were produced with different mordents like dark brown with copper sulphate, light brown with alum, black colour with ferrous sulphate and lightest brown with stannous chloride mordents, respectively as shown in figure 1.0 .

Colour fastness

Colourfastness is the term which elucidates the retention of original colour on dyed or printed fabric without fading, staining or changing when wetted, rubbed or cleaned and exposed to light under normal conditions. Table 1.0 showcases the results of fastness to light, crocking, washing and perspiration. Colourfastness of natural dyes not only depends on chemical nature and type of natural colourants, but also on type of mordents being used (Samanta and Agarwal, 2009). The results of the wash fastness revealed that, samples printed with copper sulphate, ferrous sulphate and alum portrayed good fastness to colour change followed by sample printed with stannous chloride with average fastness. The samples when tested for colour stain showcased excellent fastness with copper sulphate mordant followed by alum with good fastness. Both stannous chloride and ferrous sulphate samples showcased average fastness to colour stain, the results of the wash fastness were supported by the findings of Jothi (2008).

The colourfastness to sunlight is the property which explains how the colour of the dyed and printed fabrics resist fading when exposed to sunlight. The grading of the samples printed enlightens that the sample printed with copper sulphate mordant has excellent fastness to light. Grade six is obtained by the sample printed with alum as mordant which suggests good fastness to sunlight. Both the samples printed with stannous chloride and ferrous sulphate acquired grade 5 with moderate fastness to sunlight.

Fastness to perspiration

Fastness to perspiration is the test which reveals the effect of human perspiration on the colour or dye. The perspiration is highly dependent and varies from one individual to another. In order to forecast the effect of perspiration on dyed and printed samples, this test is conducted under acidic and alkaline conditions and rated as per grey scale. The sample printed with copper sulphate as mordant showed slight change to negligible change in colour and trivial colour staining both in acidic and alkaline conditions. Samples printed with alum

Table 1.0 Colour fastness properties of the test samples

Tested Parameter	Wash Fastness		Sunlight fastness	Crock fastness				Fastness to perspiration			
Samples				Dry		Wet		Acidic		Alkaline	
Mordants used	CC	CS	CC	CC	CS	CC	CS	CC	CS	CC	CS
Copper Sulphate	4	5	7	4/5	4	4/5	4	4/5	4/5	4	4
Alum	4	4	6	5	4	4	4	4	3/4	4	4
Stannous Chloride	3	3	5	4	4	3	3	3	3	4	4
Ferrous Sulphate	4	3	5	2	2	2	2	3	3	3	2

*CC= Colour change, CS= Colour stain

showcased very good fastness to colour change in both acidic and alkaline medium and good to very good fastness to colour stain which was supported with the findings of Zin and Moe (2008). Sight colour change and minimal staining of colour was observed in alkaline medium and good fastness to colour change and stain was observed in acidic medium for samples printed with stannous chloride as mordant. On the contrary, noticeable colour change in both acid and alkaline medium and very poor fastness to colour stain in alkaline medium was observed with samples printed with ferrous sulphate as mordant.

Fastness to crocking

The term crocking means transfer of colour from one fabric to another by rubbing. The dyed or printed fabric with good crock fastness will withstand the rubbing and the same with poor crock fastness will transfer the colour easily to the adjacent fabrics in both dry and wet conditions. The printed samples after testing with crock metre were evaluated against the grey scale and categorized from 1 to 5. The sample printed with alum and copper sulphate as mordant displayed excellent to good fastness to rubbing in both dry and wet conditions. Good fastness to crocking in dry condition is observed in samples printed with stannous chloride as mordant on the contrary, staining is observed during wet rubbing. The results were sustained with the results of Khan *et al* (2006) who reported that the cutch and ratanjot showcased moderate to good rub fastness but wet rub fastness is found to be average. Poor rub fastness to dry and wet condition was observed in sample printed with ferrous sulphate as mordant.

Subjective evaluation

The printed samples were subjected to visual evaluation in terms of depth of the colour and sharpness of prints by 30 members. Samples printed with copper sulphate and alum as mordant gained very good acceptance in terms of depth of the colour whereas, sample printed with stannous chloride and ferrous sulphate mordents has showcased good to

Table 2.0 Mean scores of subjective evaluation

Parameters	Copper Sulphate	Alum	Stannous Chloride	Ferrous Sulphate
Depth of the colour	5	5	4	3
Sharpness of prints	5	4	3	2

Weighted mean scores(WMS) 5= very good, 4= good, 3=fair, 2=Poor and 1=very poor.

fair acceptability. The mean acceptability ranged from copper sulphate > alum> stannous chloride> ferrous sulphate by different samples when observed for sharpness of prints by participants.

CONCLUSION

Natural dyes were the major source of trade throughout the history until the invention of synthetic dyes which flooded the market and replaced the natural dyes in almost all the applications. The possibility of using *Annona squamosa* L. leaf dye extract in screen printing has been explored. Four different mordants were used for preparation of print paste and the samples printed were evaluated for colour fastness and acceptability. The study proved that copper sulphate is the most suitable mordant in terms of fastness and acceptability which scored the best among all the four mordants. Further it was also proved that leaves of custard apple can be used as a natural source of printing the cotton fabric.

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