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A Study of a Coconut Calyx on Cotton and Silk for the Development of Color Palette and Designing Products Taking Inspiration from Wood Grain

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Abstract—*In this study researcher has experimented with coconut calyx dye which is remains of coconut after consuming edible portion to extract dye from it. The waste i.e. coconut calyx was tried out on myrobalan pre-treated cotton and silk with one natural mordants namely pomegranate rind and one metallic mordant alum at 2%, 4%, 6%, and 8% per cent shade at self extract pH for development of colour palette. K/S values of dyed samples were measured using spectrophotometer. Further the application of dye was done to design textiles taking inspiration from wood grain. Six cushion covers were prepared and visual assessment was taken. The arrays of colour obtained were from brownish pink to dark brown. L*a*b* values was found towards positive side which showed that dye has more red and yellow compound, most of the samples were lighter and had brighter shades. K/S values spectrophotometer analysis showed that pomegranate mordanted samples possesses good depth of colour as compared to alum mordanted samples. Further for the value addition of fabric, investigator has made an effort to design textiles taking inspiration from wood grain with the different techniques in which mordants and dyes varies at their self pH. It was said that the sample were found to be very impressive and good effects was produced by natural dyes. It was also said that it was very good idea for reducing the environment pollution. The study was very innovative and could be used for further researches. Coconut calyx dye also exhibits their use as an eco-friendly substance because it. This is not only reduces the waste but also produce eco-friendly dye.*

Keywords*: Natural Dye, Coconut Calyx, Alum.*

1. INTRODUCTION

Natural colourants covers all the dyes and pigments derived from plants, insects and minerals, i.e. derived from natural resources. The dyeing with natural colourants was one of the oldest techniques practiced by the ancient civilization people. This is evident from the Ajanta, Ellora, Sithannavasal, Mithila wall paintings (mural art) and Egyptian pyramids which had been exclusively done with natural colourants. Moreover, at the Spanish caves of Altamira and Elcatillo and French Pyrene caves of Niaux, mineral earths and other inorganic pigments like ferric oxide for red, ferrous oxide for yellow and copper carbonate for blue have been used extensively in their mural paintings. Vedas also mentioned red, yellow, blue, black and white as main dyeing colours and expressed that, the ancient craftsmen dyed blue form indigo, yellow from turmeric and saffron, brown from cutch and red from lac, safflower and madder. Thus, natural dyes have been an integral part of human life since time immemorial. **(2)**

A major break occurred in this long history during the 19th century: with the development of organic chemistry in Europe, industrialized countries generally adopted synthetic dyes and pigments extracted from fossil resources, coal-tar and oil. Cheap and easy to apply, they caused a cultural revolution. Mass synthetic colouring of everyday plastics, textiles, paints, cosmetics and food has now led people all over the world to take colours for granted. In the new era of synthetic colorants, research into natural dyes largely changed focus, shifting from economic issues to historical, archaeological and heritage aspects, until, recently, the situation changed with the global growing awareness of the threats on environment and of the need for a sustainable "green economy". **(1)**

Nowadays, however, different factors, in particular the development of alternative crops, are encouraging the re-introduction of natural dyes. The evolution of both agricultural policy, legislation regarding the use of dyestuffs in Europe, popular demand for more natural products and the toxicity problem in relation to synthetic dyes are the principal factors in encouraging a revival in the use of natural dyes. [(3)]

2. MATERIALS AND METHODS

MATERIALS

Fabrics

Cotton fabric having plain weave, weight 78.4 gms/sq^2, 37 X 29 ends and pick per cm was used for the experiment. The cotton fabric was scoured with detergent and soda ash 2gm/l at 80 ^{0}C for 30 min with MLR of 1:40 followed by rinsing with cold water and drying was carried out in air at room temperature. The silk fabric having plain weave, weight 25.48 gms/sq^2, 44 X 46 ends and pick per cm was scoured with non-ionic detergent 2gm/l at 60 ^{0}C for 30 min with MLR of 1:40 followed by rinsing with cold water and drying was carried out in air at room temperature.

Dye and mordants

For the dye coconut calyx was collected from the temple, myrobalan and pomegranate rind was collected from the market, while alum used was of laboratory grade.

Determination of preliminary data

The cotton and silk fabric chosen for the study was tested for its preliminary data which included information regarding fiber content, fabric count, weight per unit area, and thickness of the fabric.

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Table 1: Preliminary data of the fabrics

Sr. No.	Fiber content	Fabric count		Wgt/Unit area (gms/mt^2)	Fabric Thickness (mm)	Weave
		Ends Per cm	Picks Per cm			
1	100% cotton	37	29	78.4	27	Plain
2	100% silk	44	46	25.48	13.5	Plain

In the present study Coconut calyx were selected as a dye. To produce possible shades on selected substrate three mordants were selected namely alum, lemon rind and pomegranate rind.

Table 2: Preliminary data of the dyes and mordants used

Sr no.	Name of dyes and mordants	Botanical name	Class of dye based on chemical constitution	Class of dye based on its application	Colouring component	Colour obtained
1.	Coconut calyx (dye)	*Cocos nucifera*	Flavones Anthraquinone	Disperse $_{(Dye)}$	Flavogallol	Earthy Brown
2.	Harda (mordant)	*Terminlia chebula*	Tannin/Gallic & Ellagic acid	Acid$_{(Mordant)}$	Chebulinic acid [(54)]	Pale Yellow
3.	Lemon rind (mordant)	Citrus lemon	Hesperidin, Hesperetin& flavonoids[(48)]	Acid$_{(Mordant)}$	Arjunic acid	Earthy
4.	Pomegranate rind(mordant)	*punica granatum*	Tannin/Gallic & Ellagic acid	Acid$_{(Mordant)}$	Granatonine.[(20)]	Dirty Yellow

The coconut dye contains tannin group, the chemical present is flavonoids which consist of a large group of low-molecular weight polyphenolic substances, naturally occurring in fruits and vegetables, and are an integral part of the human diet. They are usually present almost exclusively in the form of glucosides and they can be divided on the basis of their molecular structure into four main groups, flavones, flavonols, flavonones and isoflavones. The flavonoid polyphenols can be oxidized by some enzymes in a very important biochemistry reaction, since the subsequent coupling reactions are involved in some biosynthetic pathways such as melanin and tannin formation. [39] Coconut dye is composed of phenolic compounds of flavonoids. Two benzoylated derivatives of polyphenolic compounds, extracted from the Coconut calyx i.e. Monobenzoyl and dibenzoyl.

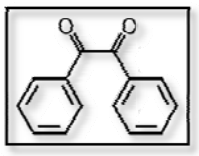

Figure 1: Monobenzoyl

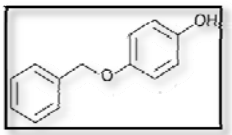

Figure 2: Dibenzoyl

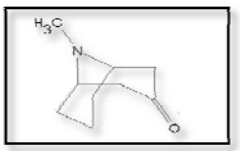

Figure 3: Granatonine

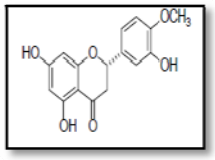

Figure 4: Hesperetin

Source: http://www.wikipedia.org.com

The fabrics dyed with pomegranate peel gave different shades of yellow, brown and black. The rind of pomegranate contains a considerable amount of tannin, about 19% with pelletierine. The main coloring agent in the pomegranate peel is granatonine which is present in the alkaloid form N methyl granatonine. This compound gives colour to the dye. [49]

METHODS

2.2.1 Treatment of mordant

The Mordanting treatment was given; the 2.5 gm of powder (lemon rind and pomegranate rind) was boiled in 250 ml of water till 45 min and then the solution was strained, the stock solution of alum was made by dissolving 2.5 gm of mordant powder in 250 ml water. And then the fabrics were treated for 45 min with each mordant separately.

2.2.2 Extraction of dye

The 1% stock solution of the dye was prepared by boiling 4 gm of dye in 100ml water for 45 min. The extract was filtered and made to 100ml and used for dyeing.

2.2.3 Mordanting and dyeing of cotton and silk

The Mordanting of cotton and silk was carried out in beakers keeping the liquor ratio 1:40. The fabrics were introduced at 60 ^{0}C and maintain the 60 ^{0}C throughout the treatment for the 45 min. After Mordanting the fabric was squeezed and dried. Then the mordanted fabrics were introduced to the dye bath prepared from the coconut calyx dye and dyeing was continued at 60 ^{0}C for the first 15 min. and then 80 ^{0}C for the 30 min at self pH. After dyeing, the fabric was squeezed and washed with cold water.

Cotton lacks affinity for the natural dyes. Hence, the use of mordant is necessary for the application of natural dyes, acid and basic dyes on cotton. While myrobalan used for pre-treatment and pomegranate rind and (mordant) contains tannin which combines with carboxylic and hydroxylic group and form bond (Figure 1).

Silk is more receptive towards mordants. This is due to its amphoteric nature wool can absorb acids and bases equally and effectively. When wool is treated with a metallic salts it hydrolyses the salt into an acidic and a basic component. The basic component is absorbed at the –COOH groups and the acidic component is removed during washing. Like wool, silk is also amphoteric and can absorb both acids as well as bases (Figure 2).

2.2.4 Evaluation of the fastness After dyeing, the materials is squeezed and washed thoroughly in running cold water followed by drying. The detailed of colour retention and fastness are measured.

2.2.4 Evaluation of the colour values

Colour value of the sample was analysed on the basis of L*a*b* values using Jaypak computer colouring matching instrument. 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 red-green axis and yellow-blue 1axis, a* and b* values were evaluated.

2.2.5 Application of dye

Further, obtained colour was used for designing of textiles. Inspiration was taken from the wood grain for the designing by using hand painting method.

3. RESULTS AND DISCUSSION

The results of the study have been given and discussed under the following:

Effect of mordants and dye on substrate

At self pH the colour of dye extract shows brown shade. Natural mordant pomegranate rind developed light yellow brown to deep yellow brown shades on fabrics. Alum shows shades of red browns on fabrics.

Evaluation of the fastness properties

The details of colour retention and fastness of the fabrics are given below:

Samples	Wash fastness		Rub fastness		Light fastness		
	Change in colour	Staining on white	Staining on white		Rating at 5 hours	Rating at 10 hours	Rating at 15 hours
			Dry	Wet			
ALD4pH	5	5	2	3	8D	8D	8DB
ALD6pH	5	5	3	2	8D	8D	8D
ALD8pH	5	5	4	3	8	8	8
LRD4pH	5	5	4	3	8D	8D	8D
LRD6pH	5	5	4	3	8D	8D	8D
LRD8pH	5	5	4	3	8	7	7
PRD4pH	5	5	4	2	8D	8D	8D
PRD6pH	5	5	3	2	8D	8D	8D
PRD8pH	5	5	4	3	8D	8D	8D

Key: AL= Alum, LR= Lemon Rind, PR= Pomegranate Rind, D= Coconut Calyx Dye

From the Table 3, it was observed that the cotton pre-treated with myrobalan had excellent fastness. Myrobalan contains 90 % tannin. It was noted that the cotton fabric pre-treated with myrobalan, alum, lemon rind, pomegranate rind gave excellent fastness to laundering after three cycle of laundering as the rating is 5. In addition, colourfastness for rubbing gave medium to good results with rating from 2 to 4, this was attributed to the fact that textured surface and superficial dye anchoring due to Vander-Wall forces was removed during Crocking test. During analysis it was also noted that in dry state all samples showed very good fastness as compared to wet state in which medium to fairly good fastness was observed. Good and excellent results were obtained for light fastness test which gave ratings of 4 to 5. All the pre-treated (with myrobalan + alum/lemon rind/pomegranate rind) samples were turned dark on 5, 10 and 15 hour exposure to light. The samples pre-treated with myrobalan and alum at 4 pH turned dark brown on 15 hour exposure to light. Only lemon rind mordanted samples at 8pH were observed to fade after 10 and 15 hour exposure to light.

Table 4: Fastness rating of coconut dyed silk fabric

Samples	Wash fastness		Rub fastness		Light fastness		
	Change in colour	Staining on white	Staining on white		Rating at 5 hours	Rating at 10 hours	Rating at 15 hours
			Dry	Wet			
ALD4pH	5	5	3	3	5D	5B	5DB
ALD6pH	5	5	4	3	5D	5DB	5DB

ALD8pH	**5**	**5**	**4**	**4**	**5**	**5D**	**5D**
LRD4pH	**5**	**5**	**4**	**4**	**5D**	**5DB**	**5DB**
LRD6pH	**5**	**5**	**4**	**3**	**5D**	**5DB**	**5DB**
LRD8pH	**5**	**5**	**4**	**4**	**5D**	**5D**	**5D**
PRD4pH	**4**	**5**	**4**	**3**	**5D**	**5DB**	**5DB**
PRD6pH	**4**	**5**	**3**	**3**	**5D**	**5DB**	**5DB**
PRD8pH	**4**	**4**	**4**	**4**	**5D**	**5D**	**5D**

Key: AL= Alum, LR= Lemon Rind, PR= Pomegranate Rind, D= Coconut Calyx Dye

It was observed from the Table 4 that the silk fabric mordanted with alum, lemon rind and pomegranate rind gave very good to excellent fastness to wash after three cycle of laundering. The readings for wash fastness for all the parameters rated 5; except the sample mordanted with pomegranate at 8pH. The colour change was observed on silk dyed samples. The sample mordanted with pomegranate in alkaline medium was observed to turn towards light green shade and slight staining on white fabric and rated 4. Silk dyed results for rub fastness rating shows rating from 3 to 4 which indicate good to excellent fastness in both dry and wet rubs. However, excellent results goes to light fastness properties as the results shown in the rating was 5 when exposed for 5, 10 and 15 hours. These results were obtained are due to good bonding of the dye molecules in the fibers as they exposed to light. The sample treated with alum at pH 4 turned slight brownish after exposure to light for 10 hours. Most of the samples on 10 and 15 exposure to light turned dark brown.

Value addition of the textile

Further for value addition of cotton fabric an effort was made to use cotton for the products. Designing was done to create beautiful grain line taking inspiration from wood grain. Numbers of wood grain photographs were captured and total six designs were selected and by hand painting method designing was done on cotton fabrics with the help of printing paste. The designed samples were used to make cushion cover for the development of products.

	**Design 1** **Description:** Gulmohar tree Vertical and diagonal lines resemble to stones.
	**Design 2** **Description:** Palm tree Horizontal and vertical lines give impression of tightly bound grass with pricking edges.
	**Design 3** **Description:** Banyan tree The design gives resemblance of ant hill with bold lines.
	**Design 4** **Description:** Palm tree The design gives impression of fish scale also it resembles pineapple.

	**Design 5** **Description:** Palm tree Bold horizontal and fine vertical lines observed which breaks the monotonous of the line with fine and smooth texture.
	**Design 6** **Description:** Neem tree The design gives idea of mosaic and whirls in water; also it resembles the cracks of earth.

PLATE 1: Selected design

Design 1	Design 2	Design 3	Design 4	Design 5	Design 6

PLATE 2: Designed cushion covers using wood grains impression

4. CONCLUSIONS

The study leads to the following conclusion:

The coconut calyx dye bears red colouring component which can be extracted in aqueous medium and applied on the textile substrate. The dye can also apply with different mordants, which affect the tone of the fibers. Both cotton (pre-treated with myrobalan) and silk have good affinity for the dye by using different mordents as the K/S values of all the dyed samples exhibited positive scores.

On cotton the dye possessed very good to excellent fastness to wash (4-5) and light (7-8). Whereas rub fastness was rated medium to good (2-4), dry rub fastness of cotton exhibited good to very good (3-4), while wet fastness of cotton is not good compared to dry rated 2-3.

In the case of silk the dye possessed very good to excellent fastness to wash (4-5) and light (7-8). Rub fastness was also good to very good (3-4), rub fastness of silk exhibited good to very good (3-4) in both the condition.

Silk showed better wash fastness to wash, light and rub as compared to cotton.

The dye was used for the further application and designing taking inspiration from wood grain with the help direct painting exhibited impressive effects on textile substrate and was appealing

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