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RESEARCH ARTICLE

DEVELOPMENT OF COLOR PALETTE USING COCONUT WASTE (HUSK) ON COTTON FOR PRODUCT LINE

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ABSTRACT

This study focuses on using agricultural waste that is coconut calyx (husk) in the form of natural dyes. An experimental research has been carried on cotton fabric using coconut calyx which is remains of coconut after consuming edible portion to extract dye from it. Fabric was dyed using two natural mordants pomegranate rind and lemon rind and one metallic mordant alum at 2%, 4%, 6% and 8% shade respectively by varying the pH values for development of colour palette. The rubbing, light and washing fastness of dyed samples were tested using standard methods. Spectro-photometric analysis of the dyed materials was carried out in terms of the CIELAB (L*, a* and b*) and K/S values with regard to dye concentration, dyeing temperature and dyeing time. The arrays of colour obtained were from brownish pink to dark brown. K/S values spectrophotometer analysis showed that pomegranate mordanted samples possesses good depth of colour as compared to alum and lemon rind mordanted samples. It was also observed that light and wash fastness properties were satisfactory except rub it from medium to fairly good. Further for the value addition of fabric researcher also 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.and visual assessment were taken. Application of wood grain print on textiles was achieved by direct hand painting. The result revealed that the effects created by painting were appealing and innovative.

INTRODUCTION

Natural dyes have been used since ancient times for coloring textiles as well as for food and cosmetics (Kadolph, 2008; Ohama, *et al.,* 2016). Although they have lost popularity with the discovery of cheaper synthetic dyes, the use of nontoxic and eco-friendly natural dyes received much attention due to the increased environmental awareness in order to avoid some hazardous synthetic colorants. The global demand for natural dyes per year is about 10,000 tones, which is equivalent to 1% of the world synthetic dye consumption (Sivakumar, *et al* 2010). It is reported that some natural dyes also be used in functional finishing of textiles such as antibacterial (Prusty *et al.,* 2010), deodorizing (Lee *et al.,* 2010), and UV protective (Yadav and Karolia, 2009). Natural dyes are generally environmental friendly and can provide a wide range of beautiful shades with acceptable levels of colourfastness. The main problem in natural colouring material is the limited source of natural colouring materials. In recent years a variety of projects have been undertaken to explore newer resources for colouring agents especially from by-products of farming and forestry. Further the present textile processing methods causes enormous damage to environment by the way of water pollution by releasing toxic chemicals, non-biodegradable dyes, total dissolved solids and sludge from effluent treatment plants. To Reduce these toxic effects on environment or human life the researcher has been concentrating research work on the investigation of new natural sources for the textile dyes available in the day to day life of the human being. Efforts are now being made to identify the raw materials from plant sources and to standardize the recipes for their use. But its availability in bulk is another problem for commercialising.

Motivation of the Study

Natural dyes provides an eco-friendly, energy-efficient alternative route for colouration of textile. Natural dye will play an important role in future, particularly, in the light of worldwide growing emphasis on the philosophy of 'suitable design', if adequate knowledge-base is developed and sufficient data-base is created on eco-friendly extraction and application methods employing Research & Development efforts. Use of coconut fruit cannot be ruled out even in future. Moreover, disposal of Coconut calyx (husk) waste has always been one of the biggest problems associated with the consumption of coconut fruit as it occupies a major portion of land fill. Its alternate use as source of dye will be a step to reduce pollution. For these reasons in the present study researchers have tried out to extract dye from the calyx of coconut as coconut is one of the fruit which is extensively used

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across the country in some or the other form. Coconut, *Cocosnucifera* L. (Family Arecaceae), is considered as an important fruit crop in the tropical countries. Currently, coconut is mainly an oil crop, rich in lauric acid, with a variety of other uses in addition to commercial oil production (Harries, 1995). Coconut is unique in terms of its fruit morphology. The fruit wall comprises of three layersexocarp, mesocarp and endocarp. Mesocarpic husk material of coconut is one of the major agro-industrial wastes generated by the developing countries each year. Lot of waste is added daily to the land fill due to the use of coconut. At present, coconut husks are mainly used as fuel for coconut processing, as a domestic fuel and as a source of fibre for rope and mats. As a traditional medicine in Brazil, coconut husks have been used for treatment of diarrhoea and arthritis (Esquenazist *et al*., 2002). The alcoholic extracts of coconut husks possess antifungal activity attributed to the high content of phenolic compounds. Antimicrobial activity of water extract of coconut husk and shell has also been reported (Singla and Jagani, 2012). Experiment was done to extract dye from coconut which is a waste after using its edible part. For the experiments dye was extracted from dry coconut powder as well as the wet coconut calyx. Dye solution was prepared and dyeing was done on cotton fabrics using pad, dry and cure method at 2% and 4% concentration of dye. Two natural mordants lemon rind and pomegranate rind and one metallic mordant alum were used in the study. The L*a*b* values were measured using Spectrophotometer. This study was carried out to study scientifically the probability of using colours obtained from waste portion of the coconut on the textiles which will reduce waste and reutilize them for the development of environment friendly colours for textiles.

MATERIALS AND METHODS

Materials

For the dye coconut calyx was collected from the temple as a waste, cleaned and ground to powder form. Two natural mordant Lemon rind and pomegranate were brought from market, and one metallic mordant i.e. alum used was of laboratory grade. Harda was used for pre-treatment of the cotton fabric. The fabrics were thoroughly scoured to remove impurities in the form of grease, dust or foreign matter. The fabrics were scoured for 45 min using soda ash and detergent (2gm/l) by boiling at a temperature of 60 ^{0}C. The material to liquor ratio was maintained at 1:40, after which fabric were rinsed thoroughly in cold water and allowed to dry.

Methods: For the current work, experimental approach was taken up in which the variables considered were- varying the mordants, varying the dye concentration, varying the dye condition (acidic, self and alkaline).

Mordanting: For mordanting; the 2.5 gm of mordant powder (lemon rind and pomegranate rind separately) 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 samples were treated for 45 min with each mordant separately.

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.

Dyeing and mordanting of cotton fabric: The Mordanting of sample was carried out in beakers keeping the material liquor ratio 1:40. The samples were introduced at 60 ^{0}C and temperature was maintained throughout the treatment for the 45 min. After mordanting the samples were squeezed and dried. These mordanted samples were introduced to the dye bath prepared from the coconut calyx dye and dyeing was carried out at 60 ^{0}C for the first 15 min. and then at 80 ^{0}C for further 30 min. The four concentrations were selected for dyeing 2%, 4%, 6% and 8%. After dyeing, the samples were squeezed, washed with cold water and dried.

Color strength and color depth measurements: The samples after dyeing were assessed for their C.I.E. Lab and K/S values using spectrophotometer.

Fastness properties of dyed Cotton: The color fastness to washing, light and rubbing cotton fabric dyed by coconut husk extract under optimum condition were determined according to A.A.T.C.C. test method IA 61-1962, A.A.T.C.C. test method 16A-1963 and A.A.T.C.C. test method 8, 1991 respectively.

Designing taking inspiration from wood grain: The developed colour palette was used for designing of textiles. Some combinations were tired out for preparations of a product i.e. cushion cover by taking inspiration from wood grain.

Printing of textile: Printing was done with using printing paste from tamarind seeds powder by dissolving 10gms of powder in 100ml of water. Dye and mordant extract was mixed in paste to produce desirable shades according to the need of designs. With the help of brush direct painting was done and after treatment was given to cure the colour.

Visual assessment of the product : Visual assessment of prepared cushion cover in terms of overall aesthetic appeal and colours and effects produced.

RESULTS AND DISCUSSION

Preliminary data of the fabric: The results of preliminary data of fabric revealed that the fabric selected were 100% cotton fabric count 37 X 29 ends and pick per cm, GSM 78.4 gms/sq2 and thickness 27 mm have plain weave.

Evaluation of the colour yield: 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. This dye is composed of phenolic compounds of flavonoids. Two benzoylated derivatives of polyphenolic compounds, extracted from the Coconut calyx i.e. Monobenzoyl and dibenzoyl shown in Figure 1 in Figure 2.

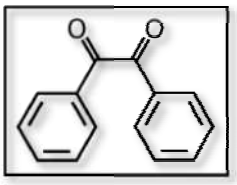

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Figure 1. Monobenzoyl

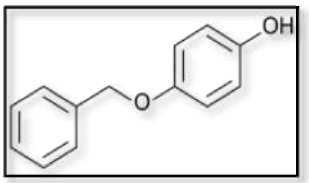

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Figure 2. Dibenzoyl

Colour palette and reflectance spectrophotometer data obtained through selected dye and mordants (metallic and natural), pH variation. Different shades of brown, yellow and pink were obtained under different conditions which are given in Table 1.

Table 1. Colour obtained with different variables

Condition	Self pH	Acidic pH	Alkaline pH
Without mordant	Brown	Orange brown	Red brown
Pomegranate rind	Light yellow brown	Light yellow brown	Yellow brown
Lemon rind	Light brown	Light brown to pink	Pink
Alum	Red brown	Red brown	Pink

Total range of 36 shades on substrate were obtained. It was observed that Coconut offered a large range of noticeably different shades with respect to brownish pink, light brown, yellow brown dark brown depending on the interference from the mordants they were pre-treated with. It was observed that the cotton samples treated with alum had more red and yellow component and also brighter shades. It was also observed that as the concentration increases the colour component also increase. And acidic and extract pH showed best results as compared to alkaline medium. Samples dyed in alkaline medium had brighter shades.

Assessment of colour values of the dyed samples: A gamut of 36 shades was obtained. The L* values explain lightness and darkness in the samples. a* describe presence of red and green colour component on mordanted and dyed sample, if value + it has red colour component while – values show presence of green colour component. b* describe presence of yellow and blue colour compound, if + it has yellow colour component while – values shows presence of blue colour component. K/S values depict the colour depth in the shade. To assess the relative colour strength of dyed cotton fabrics with different mordants at different percent dye concentration, K/S values are determined.

Effect of Alum on dyed cotton with different percent concentration and different pH: Table 2 demonstrate the effect of alum on different pH and percent dye concentration for dyeing of cotton fabrics. It is clear that the deepest colour was acquired by sample dyed at 8% in acidic medium (8.934) and followed by sample dyed with same concentration at self pH (8.051)

Effect of lemon rind on dyed cotton with different percent concentration and different pH: K/S values of lemon rind treated cotton fabric at different %shade is evident from Table 3 that; the maximum depth of colour was seen in sample dyed at 4% (17.058) followed by sample dyed with 8% shade at acid pH.

Effect of pomegranate on dyed cotton with different percent concentration and different pH : Table 4 exhibits K/S values of cotton pre-treated with myrobalan and mordanted with pomegranate rind, the higher colour depth was acquired by sample dyed with 8% in alkaline medium (39.723) and followed by sample dyed with 2% shade same in alkaline medium (33.137).

Colourfastness of cotton fabric dyed with coconut husk: It was observed from the table 5 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.

Designing and painting by taking inspiration from wood grain

Sample Preparation

Further for the value addition of cotton fabric, investigator has made an effort to use the cotton for the products. The fabric selected was first scoured for removing any impurities and size. For scouring, the fabric was heated in the solution containing non-ionic liquid detergent of 2gms/lit for 60 min at the temperature of 60^0 C. The material to liquor ratio taken was 1:40. The fabric was finally rinsed thoroughly in running water and dried. After scouring according to the design two samples were pre-treated with harda to get yellow shade. The fabric was then thoroughly rinsed in running water, dried and ironed properly. The samples were then cut in 25cm X 25 cm pieces.

Selection of design

For the inspiration of designing, photograph of wood grain texture were collected from the "Kamati Garden", Fatehgunj, Vadodara.

Development of Design: The outlines of the designs were drawn directly with help of "0" number of painting brush by using dye paste and design was filled by using "3" and "12" number paint brush. Different mordants (Alum, Lemon rind and Pomegranate rind) were used to develop colours according to the need of design. Then the samples were allowed to dry for 24 hours, steamed (20 min), rinsed thoroughly to remove printing paste from the surface and dried. a product i.e. 6 cushion covers by taking inspiration from wood grain. After experimenting with dye, pH, percentages and mordants, some combinations were tried out for preparations of a product i.e. 6 cushion covers by taking inspiration from wood grain (Plate3).

Table 2: Effect of percent concentration of dye on CIELAB values of cotton treated with alum at different percent concentration

Samples	% Conc	L*	a*	b*	C*	DL*	DE*	K/S
Control		61.055	1.977	15.981	16.13	---	----	14.467
AD 6pH	2%	53.945	7.138	21.638	22.785	-7.110	10.449	7.285
AD6pH	4%	53.136	8.018	22.075	23.486	-7.919	11.677	6.561
AD4pH	6%	54.391	7.871	22.875	24.191	-6.6664	11.255	6.813
AD4pH	8%	50.862	9.202	23.275	25.028	-10.193	14.467	8.934

Table 3: Effect of percent concentration of dye on CIELAB values of cotton treated with lemon rind at different percent concentration

Samples	% Conc.	L*	a*	b*	C*	DL*	DE*	K/S
Control		61.055	1.977	15.981	16.13	---	---	14.467
LD4pH	2%	59.168	5.518	16.466	17.366	-1.887	4.042	13.706
LD4pH	4%	57.875	60552	15.655	16.971	-3.183	5.583	17.058
LD4pH	6%	55.557	7.566	17.502	19.067	-5.498	7.986	14.949
LD4pH	8%	54.241	8.981	17.568	19.731	-6.814	9.900	15.480

Table 4: Effect of percent concentration of dye on CIELAB values of cotton treated with pomegranate at different percent concentration

Samples	% Conc.	L*	a*	b*	C*	DL*	DE*	K/S
Control		61.055	1.977	15.981	16.13	---	---	14.467
PD6pH	2%	61.228	4.070	17.244	17.781	0.173	2.451	33.137
PD6pH	4%	58.211	6.396	20.009	21.006	-2.844	6.621	17.136
PD8pH	6%	61.759	4.515	18.904	19.436	0.704	3.935	22.607
PD8pH	8%	65.005	8.457	21.090	22.722	-5.050	9.674	39.723

Table 5: Fastness rating of coconut dyed and pre-mordanted cotton fabric

Samples	Wash fastness		Rub fastness		Light fastness		
	Changein 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	5D	5D	5DB
ALD6pH	5	5	3	2	5D	5D	5D
ALD8pH	5	5	4	3	5	5	5
LRD4pH	5	5	4	3	5D	5D	5D
LRD6pH	5	5	4	3	5D	5D	5D
LRD8pH	5	5	4	3	5	4	4
PRD4pH	5	5	4	2	5D	5D	5D
PRD6pH	5	5	3	2	5D	5D	5D
PRD8pH	5	5	4	3	5D	5D	5D

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

Plate 1. Collection of wood grain photograph

Design 1
Description: Gulmahor 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.

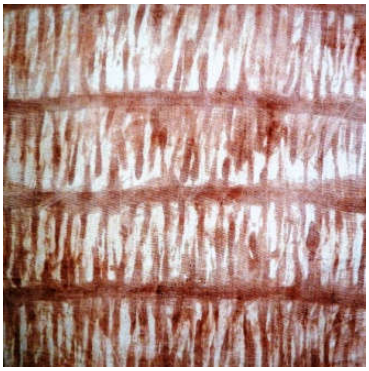
Design 4
Description: Palm tree
The design gives impression of fish scale also it resembles pineapple.

Design 5
Description: Palm tree
Bold horizontal and fine vertical lines 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 2. Selected design for cushion covers

Design 1

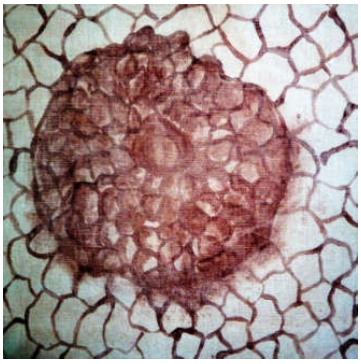


Design 2

Design 3

Design 4

Design 5



Design 6

Plate3: Hand Painted designs on cotton fabric with or without myrobalan treatment

Evaluation of Cushion covers in terms of overall aesthetic appeal and colours and effects produced

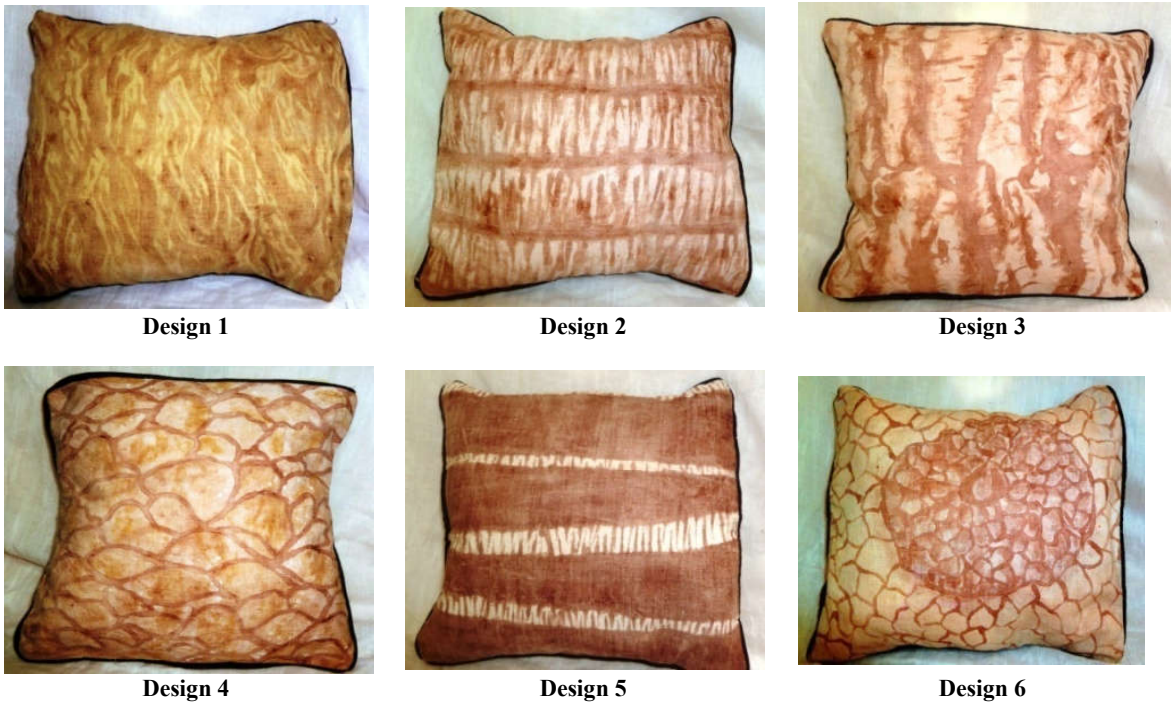


Plate 4. Designed cushion covers using wood grain impression

Evaluation of Cushion covers in terms of overall aesthetic appeal and colours and effects produced

Cushion cover painted with natural dye was very impressive (Plate 4). The effects created by painting by varying mordants and pH were appealing. It was very good idea as a contribution to the green environment. The study was very innovative and could be used for further researches. This is an innovative study which can be used for further researches and for creation of beautiful textiles which will be environment friendly also.

Conclusion

The study has demonstrated that coconut husk which is waste material could be effectively used as a dyeing agent with moderately good results. Dyed cotton fabrics showed different shades of brown, yellow and pink colour. Best results were obtained at 8% shade in acidic condition with alum. Cotton treated with lemon rind gave best results at 4% in the self pH(6pH). Pomegranate treated cotton showed maximum values in alkaline conc. with 8% of dye. Overall the value obtained on cotton with pomegranate rind showed higher colour depth followed by lemon rind and alum. The fastness properties i.e. rubbing fastness, washing fastness, and light fastness of tested dyed fabrics were also found to be satisfactory. Hence, it was inferred that coconut husk lead to good dye ability of cotton fabrics. The dye was used for further application and designing taking inspiration from wood grain with the help direct painting exhibited impressive effects on textile substrate and was appealing. It can be concluded that the natural dye from coconut husk can be applied as commercial natural dyestuff for cotton products.

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