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Eco-friendly Dyeing of Cotton & Silk Fabric with Husk of Coconut (*Cocos nucifera*)

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Abstract

Coconut husk of dark brown colour was selected as dye source and pigment extracted from husk and it was utilized for dyeing of cotton and silk fabric. Optimized various dyeing conditions as time required for extraction of pigment , time for dyeing of fabric ,concentration of dye source, to make the dye permanent different metallic salts(mordants) were taken such as Feso4, Alum, and Cuso4 and for dye fixation post mordanting method was used. Colour strength of extracted pigment, dyed fabric and mordanted fabric was measured by using colour measuring instrument Tinctometer. Colour fastness properties were tested of dyed and mordanted fabric such as washing, rubbing, perspiration, sunlight and hot pressing. Result revealed that 30 minutes time period was found to be sufficient for extraction of pigment as well as for dyeing of fabric, 2 gm concentration of dye source was found to be enough for dyeing of one gram of cotton fabric and one gram silk fabric and post mordanting method for dye fixation was found to be excellent method. Selected mordants make the dye fast as well as developed various shades on fabric. On cotton fabric colour shade produced as light brown , dry leaves brown, light smoke grey .On silk fabric colour shade developed as golden brown , light brown, dry leaves brown and dark smoke grey. Colour fastness properties of silk fabric were found to be excellent and colour fastness on cotton was found to be good to fair. Coconut husk is environmentally eco-friendly, nontoxic and successfully utilized as a good source of dye for cotton and silk fabric and after dyeing fibers of coconut husk reused for industrial products

Key words: coconut husk, dyeing, cotton fabric, silk fabric, dye fixation, post mordanting, Colour fastness.

Introduction

Coir is the name given to the fibrous material that constitutes the thick mesocarp (middle layer) of the coconut fruit (*Cocos nucifera*). The husk of the coconut contains approximately 75 per cent fibre and 25 per cent fine material, the so-called „coir pith". Husks are often soaked in water to soften them and facilitate grinding. When the coconut husks are being processed, the coco dust is separated from the fibre. The long fibers of coir extracted from the coconut husk are used in the manufacture of industrial products, for example mats or ropes. Traditionally the dust and small fibers were left behind and accumulated as a waste product .A research work is carried out in the Department of Textiles & Apparel Designing, College of Community Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani on Eco-friendly Dyeing of Cotton & Silk Fabric with Husk of Coconut (*Cocos nucifera*) on 2022 by considering the objectives such as optimization of various dyeing conditions as time for extraction of pigment, time for dyeing & concentration of dye source required , effect of mordants on dye fixation and testing of colour fastness properties of dyed and mordanted cotton & silk fabric. In industry making products of coir the husk of coconut is soaked in water to make it soft , due to soaking pigment of husk is extracted in water that is dark brown colour and this pigment is going waste ,if industry is utilized pigment of coconut husk for dyeing of fabric and soft husk used for product making it is double benefited because pigment of coconut husk is eco-friendly , non-hazardous, not volatile, economical for dyeing of cotton and silk fabric , and coir fiber can be used for preparation of product in cottage industry as well as at home after using of coconut.

Methodology Selection of Dye Source

Husk of fully ripened coconuts of brown variety was selected as dye source for dyeing of cotton and silk fabric. Coconut is oilseed, botanical name is *Cocos nucifera, coconut husk content* Pigment Tannins and it is brown colour and water soluble. One coconut of medium size content approximately 250 gram husk

Selection of fabric

Grey cotton fabric of plain weave 70 x 60 count and silk fabric of plain weave of 80 x 90 count was selected.

Collection of dye source

Dried brown coloured coconut fibrous husk was collected from the Temple and Dargha (religious place) and also purchased one coconut of brown colour of medium size (length 10 inches circumference 15 inches) from the local market at rate of Rs 25/- (Rs twenty five only) because to know amount of husk in get from one coconut

Selection of mordants (metallic salts)

Different mordants were selected such as pure alum, copper sulphate and ferrous sulphate for dye fixation and also for development of various shades on fabric. Post mordanting method was adopted for dye fixation.

Preparation dye source

Brown colour husk Fibrovascular bundles were removed from the shell by combing and crushing, fibers were separated from the short spongy tissue (dust particle) . Fibers and short spongy dust particles both were utilized for

extraction of pigment, because from the bundle of coconut husk pigment yield is found less amount. **Optimization of time for extraction of pigment**

Prepared dye source (fibers and short spongy dust particles) was added in the six beaker containing 1gm/100 ml of water and it was brought to boiled for various selected time scale as 10, 15,20,25,30,35 and 40 minutes for extraction of pigment. The beakers were removed from gas and colour strength of extracted pigment of each time scale was measured with the help of colour measuring instrument "Tinctometer" and colour rating was noted.

Optimization of dye material concentration

One gram of cotton fabric and one gram of silk fabric and different concentration of dye source as 1gm, 1.5gm , 2gm , 2.5gm , 3gm , 3.5gm and 4gm were added in the seven beakers containing 100 ml of water .The beakers were kept on gas stove for dyeing of fabric Dyeing was carried according to optimized time of dyeing i:e 30 minutes. Dyed fabric of each concentration was washed and dried in shade. The colour strength of dyed fabric of each concentration was measured separately with the help of colour measuring instrument "Tinctometer" and colour strength rating and colour obtained on fabric was recorded.

To reduce the cost of dyeing

For reducing the cost of dyeing, various steps of dyeing was cut down to save time and fuel, such as extraction of pigment, preparation of cotton (desizing, scouring) and degumming of silk fabric

Method of Dyeing

A unified process of dyeing was carried out for reducing cost of dyeing and to save time and fuel Optimized concentration of dye source 2 gram / 1gram of cotton & 2gm/1gm of silk fabric and water 400 ml were added at a time in stainless steel vessel and dyeing carried out with optimized time period for 30 minutes .Dyed sample was washed and dried in shade, obtained colour shade on cotton & silk fabric was noted by matching with the shade card. Colour strength of dyed fabric was measured using colour measuring instrument "Tinctometer" and colour strength rating was recorded.

Method of mordanting

Post mordanting method was selected for dye fixation. Cotton and silk fabric was dyed first with coconut husk then mordanted with selected mordants .Optimized concentration of mordant was dissolve in warm water and dyed fabric was soaked in mordant solution for dye fixation with optimized time scale for 15 minutes. Colour developed on fabric with the reaction of mordants was recorded and also colour strength of mordanted fabric was measured with colour measuring instrument Tinctometer.

Colour identification

Developed colour shade on cotton & silk fabric without mordanted (control sample) and mordanted samples with alum ,ferrous sulphate and copper sulphate were visually evaluated and matched with the shade card and match colour of fabric with shade card was noted

Testing of colour fastness properties

The resistance of colour of sample to fade or bleed against different agencies is sun light, washing fastness with water rubbing with Crockometer. Dyed cotton and silk fabric without mordanted (control sample) & mordanted sample were tested for colour fastness properties

Evaluation of colour fastness test

The colour fastness test was carried out as per the SDC (society of Dyer and colorist) recommended by ISI Indian standard Institute, Grey scale for colour changing and Grey scale for staining rating from excellent to poor numerical rating from 5 to 1 respectively.

Washing fastness test

Specimen preparation of colour fastness to washing as the dyed mordanted samples and white fabric of same fabric were cut in size of 4x3 inches and one white piece of fabric and one piece of dye fabric stitched by hand from three side, cotton sample was soaked in mild detergent .silk samples were soaked in the Ezzy liquid soap for an about 30 minutes. White piece of fabric and dyed sample were separated and examined by loss or bleed colour from dye sample and staining on white fabric **Sun light Fastness test**

Dyed sample was prepared for sun light fastness test as sample of 8x4 inches was cut and marked one inch division of 8 division on sample and it was kept in register and each division of one inch was exposed in sun light in this manner seven division exposed in sun light for seven days .First division exposed in light for seven days so it was compared with original dyed sample with the help of grey scale and rating and grading was given by using gray scale of Blue Wool Standards, fastness grading as excellent, very good, good, fair and poor and numerical rating as 5 to 1 respectively

Rubbing fastness test

Rubbing fastness testing crockometer meter was used and original dyed sample of 8x8 inches in size was cut and fixed in base of crockometer and 2x2 inches of white fabric (dry)was fixed in nozzle of upper part of crockometer and 10 rubbing stroke was carried out against dyed fabric In the same manner damp white fabric was fixed and 10 rubbing stroke was carried out against dyed fabric. Colour transferred on white fabric in dry and damp were assessed with the help of grey scale and rating and grading was given by using gray scale of Blue Wool Standards, fastness grading as excellent, very good, good, fair and poor and numerical rating as 5 to 1 respectively **Findings**

Optimization of dye extraction time

Table-1 showed that colour strength rating of extracted pigment of coconut husk measured by Tinctometrically. It was observed that higher colour strength rating 15R5Y8B was found at 30 minutes time scale and colour pigment was visually observe as dark brown colour, as the time for extraction of pigment was increases from 35 to 40 minutes .Colour strength rating of extracted pigment was found to be constant. Hence it was clear that 30 minutes time for extraction of pigment was found to be sufficient. It was further observed that pigment of coconut husk was found in the combination of red, yellow and blue pigment .Red pigment is more (15) followed by blue (8) and yellow (5) .

Table-1.Optimization of time for extraction of pigment from coconut husk

S.no	Time of extraction (minutes)	Colour strength rating by Tinctometrically	Visually colour observe
1	10	5R1Y1B	Light brown
2	15	8R3Y5B	Tea brown
3	20	10R4Y6B	Tea brown
4	25	14R4Y7B	Dark brown
5	30	15R5Y8B	Dark brown
6	35	15R5Y8B	Dark brown
7	40	15R5Y8B	Dark brown

(R- red, B- blue and Y – yellow)

Table.2 showed that optimization of dye material concentration for dyeing of fabric.

Cotton

Lower colour strength rating 5R2Y2B was noted at the concentration of dye material used for dyeing of cotton such as 0.5mg ,1 gm and 1.5 gm and colour shade obtained on fabric as light brown . Higher colour strength i;e **8R4Y2B** was recorded on cotton at concentration of dye material of 2 gm./ gm. of fabric and colour shade developed as dry leaves brown. As the concentration of dye material was increases from 2.5 to 4 gm, color strength rating was found to be constant and no change was seen in the colour shade. It means that 2 gram of dye material was found to be enough for dyeing 1 gram of cotton

Silk

In case of silk fabric higher colour strength rating i;e **13R5Y8B** as recorded at concentration of dye material of 2 gm/ gm of fabric was used and colour shade developed beautiful **Golden brown.** As the concentration of dye material was increases from 2.5 to 4 gm, color strength rating was found to be stable and no change was seen in the colour shade. It means that 2 gram of dye material was found to be enough for dyeing 1 gram of silk fabric

Table-2.Optimization of concentration of dye source for dyeing

S.no	Concentration of dye material/ fabric (mg/gm)	Time for dyeing minutes	Colour strength of dyed fabric Tinctometrically	Colour Shade developed	Colour strength of Tinctometrically)	Colour Shade developed
			Cotton		**Silk**	
1	0.5	30	5R2Y2B	Light brown	5R2Y2B	Light brown
2	1	30	5R2Y 2B	Light brown	5R2Y2B	Light brown
3	1.5	30	5R2Y 2B	light brown	**8R4Y 2B**	Brown
4	**2**	**30**	**8R4Y2B**	**Dry leaves brown**	**13R5Y8B**	**Golden brown**
5	2.5	30	8R4Y2B	Dry leaves brown	13R5Y8B	Golden brown
6	3	30	8R4Y2B	Dry leaves brown	13R5Y8B	Golden brown
7	3.5	30	8R4Y2B	Dry leaves brown	13R5Y8B	Golden brown

R- Red, B- blue and Y – yellow

Table-3(A).Optimization of mordants concentrations of alum, ferrous sulphate & copper sulphate used for dye fixation for cotton fabric

Concentrations of mordants(mg/gm)	Time for mordanting minutes	Cotton fabric Tinctometrically Colour strength rating					
		Alum		Ferrous sulphate		Copper sulphate	
		Colour strength rating	Colour shade developed	Colour strength rating	Colour shade developed	Colour strength rating	Colour shade developed
0.2	15	5R2Y 1B	Light brown	8R2Y 2B	Light smoke grey	10R2Y 1B	Light brown
0.4	**15**	**10R4Y 2B**	**Dry leaves brown**	**10R2Y3B**	Light smoke grey	12R2Y 1B	Light brown
0.6	**15**	10R4Y 2B	Dry leaves brown	**13R2Y 2B**	**Dark smoke grey**	10R2Y 2B	Light brown
0.8	15	10R4Y 2B	Dry leaves brown	13R2Y 2B	Dark smoke grey	**12R2Y 2B**	**Dry leaves brown**
1.0	15	10R4Y 2B	Dry leaves brown	13R2Y 2B	Dark smoke grey	12R2Y 2B	Dry leaves brown
1.2	15	10R4Y 2B	Dry leaves brown	13R2Y 2B	Dark smoke grey	12R2Y 2B	Dry leaves brown
1.4	15	10R4Y 2B	Dry leaves brown	13R2Y 2B	Dark smoke grey	12R2Y 2B	Dry leaves brown

R- red, B- blue and Y - yellow

Table-3(a) indicates that optimization of mordant concentrations on cotton fabric alum , ferrous sulphate and copper sulphate for dye fixation .

Alum

Dark smoke grey colour was developed on cotton when mordanted with 0.4 mg alum for per gram of fabric, as concentration alum increases from 0.6 mg to 1.4 gm. No change in colour was seen colour shade and colour strength rating was found to be constant. It was clear from the result that 0.4 mg of alum mordant was found to be sufficient for the dye fixation on cotton.

Ferrous sulphate

In case of ferrous sulphate mordants used for mordanting at the concentration of 0.6 mg /gram of fabric received higher colour strength rating 12R2Y 2B and obtained **Dark smoke grey ,** as the concentration of ferrous sulphate were increases from 0.8 mg to 1.4 gm, no change observed in colour rating as well as in colour. It was clear from the result that 0.6 mg of ferrous sulphate mordant was found to be sufficient for the dye fixation.

Copper sulphate

In case of copper sulphate mordant used for dye fixation higher colour rating Tinctometrically Was observed 12R2Y 2B at the concentration of 0.8mg / gram of cotton fabric and dry leaves brown colour shade was developed. As the concentration of copper sulphate were increases from 1 to 1.4 gm no change was observed in colour and in the colour strength rating . It was clear from the result that 0.8mg of copper sulphate mordant was found to be sufficient for the dye fixation on cotton fabric.

Table-3(B).Optimization of mordants concentrations of alum, ferrous sulphate & copper Sulphate used for dye fixation

Concentrations of mordants(mg/gm)	Time for mordanting minutes	Silk fabric Tinctometrically Colour strength rating					
		Alum		Ferrous sulphate		Copper sulphate	
		Colour strength rating	Colour shade developed	Colour strength rating	Colour shade developed	Colour strength rating	Colour shade developed
0.2	15	5R2Y 1B	Light brown	4R1Y 5B	Light smoke grey	5R2Y 1B	Light brown
0.4	15	6R2Y 2B	Light brown	4R1Y 6B	Light smoke grey	6R2Y 1B	Light brown
0.6	15	10R2Y 2B	dry leaves brown	4R1Y 6B	Light smoke grey	8R2Y 2B	Light brown
0.8	**15**	10R2Y 2B	Dry leaves brown	**4R2Y 10B**	**Dark smoke grey**	10R2Y 2B	light brown
1.0	**15**	**14R2Y 2B**	**Dark brown**	4R2Y 10B	Dark smoke grey	**12R2Y 2B**	**Dark dry leaves brown**
1.2	15	14R2Y 2B	Dark brown	4R2Y 10B	Dark smoke grey	12R2Y 2B	Dark dry leaves brown
1.4	15	14R2Y 2B	Dark brown	4R2Y 10B	Dark smoke grey	12R2Y 2B	Dark dry leaves brown

R- red, B- blue and Y - yellow

Table-3 (B) illustrates that optimization of mordants concentrations of alum, ferrous sulphate and copper sulphate used for dye fixation for silk fabric.

Alum and copper sulphate

Alum and copper sulphate both the mordants developed dark dry leaves brown colour at concentration of 1 mg/gm of silk fabric .As concentration of alum and copper sulphate were increases from 1.2mg to 1.4 gm color and colour strength rating was found to be constant i;e 14R2Y 2B (alum) and **12R2Y 2B(copper sulphate) .** It was clear from the result that 1mg of alum and copper sulphate were found to be sufficient for dye fixation on silk

Ferrous sulphate

In case of ferrous sulphate mordant higher colour strength rating i;e 4R2Y 10B was recorded of silk fabric at concentration of 0.8 mg /gram of fabric and obtained dark smoke grey. As the quantity of mordant of Feso4 was raised up to the 1 to 1.4gm for dye fixation, the colour strength was found to be constant and no change was noticed in dark smoke grey colour shade. It was clear from the result that 0.8mg of Feso4 was found to be sufficient for dye fixation on silk fabric Table-4(a). Colour Fastness properties of cotton fabric

S.no	Mordants	Colour obtained	Cotton fabric -Colour fastness rating			
			Washing	Sunlight	Rubbing	
					Dry	Wet
1	Without mordanted (Controlled sample)	Light brown	3	3	3	3
2	Alum	Dry leaves brown	4	4	4	3

3	Feso4	Light smoke grey	4	4	4	3
4	Cuso4	Dry leaves brown	3	3	3	3

Very good-4, good-3 ,

Table -4(a) showed that Colour Fastness properties of cotton fabric dyed with pigment of coconut husk and mordanted with selected mordants .It was observed that colour fastness properties of washing, rubbing and sunlight of without mordanted samples was found to be good with fastness rating as about to 3 . It was observed that colour fastness properties of cotton fabric mordanted with, Alum and Feso4 were found to be good to very good and fastness rating noted as about 4 to 3. In case of Cuso4 mordant colour fastness properties was recorded as good with fastness rating as about to 3. Form the result it was clear that mordants Alum, Feso4 & Cuso4 were effective & suitable and showed excellent performance for dye fixation and developed light brown colour ,dry leaves brown colour, light smoke grey colour respectively . Table -4(b). Colour Fastness properties of silk fabric

S.no	Mordants	Colour obtained	Cotton fabric -Colour fastness rating			
			Washing	Sunlight	Rubbing	
					Dry	Wet
1	Without mordanted (Controlled sample)	Golden brown	5	4	4	4
2	Alum	Dark brown	5	4	4	4
3	Feso4	Dark smoke grey	5	4	4	4
4	Cuso4	Dark dry leaves brown	5	5	4	4

Excellent-5, very good-4,

Table -4 (b). Illustrate the Colour Fastness properties of silk fabric dyed with pigment of coconut husk and mordanted with selected mordants .It was observed that colour fastness properties of washing, rubbing and sunlight of without mordanted silk fabric was found to be excellent to very good and fastness rating was noted as about to 5 to 4 respectively. It was observed that colour fastness properties of silk fabric mordanted with, Alum , Feso4 and Cuso4 were found to be excellent to very good with fastness rating as about 5 to 4. Form the result it was clear that mordants Cuso4, Alum and Feso4 were found to be suitable and showed excellent performance for dye fixation and produced good colour shade on silk such as golden brown, dark brown, dark smoke grey and dark dry leaves brown colour respectively.

Conclusion

It can be concluded from the study that pigment of coconut husk is suitable for dyeing of cotton and silk fabric and produced very good colour shades on cotton fabric as light brown, dry leaves brown, light smoke grey and on silk developed beautiful golden brown, dark smoke grey and dry leaves brown. Excellent colour fastness was seen in silk fabric and very good colour fastness was showed in cotton. Coconut husk is environmentally eco-friendly, good source of dye material.

After dyeing fibers of coconut husk can be reused for preparing different products

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S.no	Mordants	Shades obtained on cotton	Shades obtained on silk
1	Without treatment of mordant (Controlled sample		
2	Alum		
3	Feso4		
4	Cuso4