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Study of the effect of detergents on the wash fastness properties of naturally dyed cotton fabric using the Grey scale method

[a*]**Andrea Sandra Christine D'Cruz**

Department of Science and Humanities, St. Martin's Engineering College, Secunderabad, Telangana 500100, India

Corresponding author email id: **andydcruz19@gmail.com**

Abstract

Natural dyes are of intriguing interest as they are widely known to be nontoxic, eco-friendly, easily available as well as safe for use. They serve as the new substitutes for synthetic dyes in the food and cosmetics industry besides several others. They are best used in the textile industry for dyeing fabrics and are known to show good fastness properties. In this paper, wash fastness properties was studied on naturally dyed cotton fabric. The aim of this work was to study the wash fastness of the dyes by washing them with popular detergents. The colour strength and wash fastness for the dyed cotton fabrics were evaluated and compared using the Grey scale method. The studies revealed that the dyeing property of the fabrics after washing with water and different detergents was not affected much. It can be concluded that the naturally dyed fabrics have good dyeing and wash fastness property.

Keywords: natural dyes, good fastness, light fastness

Introduction

Over the last few decades, there has been an exponential growth in the dyeing industry sector. This is due to its varied applications in the fields of food, cosmetics, drugs, textiles, plastics, automobiles and lots more **[1,2]**. In general, dyes can be best described as a useful necessity. India has a rich history of natural flora and fauna **[3]**. Some of the dyes are derived from naturally occurring sources such as plants, insects, animals, and minerals **[4]**. For example indigo, extracted from the indigo plant yields the blue dye which is used in the textile industry especially in jeans. Whereas, cochineal also used in textiles are obtained from insects. It is no wonder that a large number of natural dyes having a varied shade of colours can be obtained from nature **[5,6]**. Cities like Rajasthan, Gujarat and many others are still involved in many traditional practices of textile dyeing using natural dyes. Colour fastness and wash fastness are some of the very important properties of a pigment or dye in the textile industry. Colour fastness is a term used in the dyeing of textile materials which indicates fading or running of colour **[7]**. Colour fastness to washing is the ability of the fabric to withstand the action of detergents used. Washing of the fabric helps in removal of the dye to some extent thereby causing staining in some cases. The shade change are thus checked for the effects of bleeding or colour migration. There are a number of reasons for fading of clothes. Colour fastness arises due to light, wash,

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water, crocking, abrasion, frosting, rubbing, perspiration and heat or due to various gases in the atmosphere **[8-10]**. Most natural dyes have poor to moderate light fastness as compared to synthetic dyes. This can be mainly attributed to their different chemical as well as physical properties. The loss or change in the colour of the dyed textiles upon exposure to light is a complex reaction affected by both the chemical and physical state of the dye. External factors such as the source and intensity of illumination are also known to alter the reaction as well. When the chemical structure of a dye affects its light fastness properties, the physical state of the dye generally becomes more important than the dispersed dye within the fiber and hence it fades more rapidly. Fibers with large aggregates of dye are most light fast, since a smaller surface area of the dye is exposed to air and light. Other factors of light fastness may also include the choice of fabric used, type of dye involved, the procedure/process as well as the action of detergents.

However the use of natural dyes for dyeing has a number of disadvantages such as low colour yield, complex nature of the dyeing process, difficulty in reproducing the shades, obtaining minimum shades as well other problems such as their fastness properties **[4]**. In 1856, William Perkins discovered synthetic dyes which served as a big boon to the dyeing industry. After the initial discovery a large number of synthetic dyes came into existence. It predominantly took over the entire industry as compared to natural dyes in order to compete with growing market standards and demands. Synthetic dyes were mostly preferred because of their low cost and varied shades that showed considerable improved colour fastness and wash fastness properties **[11]**. In textile dyeing, in order to avoid such problems, dyes are tested for various parameters such as colour fastness to wash fastness property. A major disadvantage is that several synthetic dyes/colourants are known to contain harmful chemicals such as volatile organic contents (VOC). VOC's in paints, are responsible for respiratory problems such as breathing, asthma, burning of skin and eyes and other related diseases that causes allergies or are carcinogenic in nature **[12]**.

The development of a large number of synthetic dyes that contain harmful chemicals which are not safe for the Earth has raised concerns for the increasing demand of the use of natural dyes for a better and safer environment **[13,14]**. Thus the structures and useful properties of natural dyes have been taken into consideration only in the recent past. For example in medicines, high demand for natural dyes is mainly due to the increased awareness on the therapeutic properties of the dyes. Besides this, in the textile industry, natural dyes offers good colour strength value, has less dye exhaustion percentage, and offers better colour fastness properties as compared with synthetic dyes **[15,16]**. There are also comparatively less toxic and also economical. Environmentalists as well as industrialists are hence spreading more information about the need for a clean, green as well as substainable environment that will not only be healthy to the workforce but also to mankind **[17]**. Researchers are therefore striving to obtain new natural dyes that will help serve as a viable option for our dye needs **[18]**.

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In this paper, the wash fastness of naturally dyed cotton fabrics which were subjected to varying concentration of washings using different detergents and the effect of detergents on the fabrics was carried out and reported.

Materials used

Fabric used: A multi-coloured cotton fabric dyed with a range of colours using natural dyes was obtained from Natural Dye Resources, Dahisar, Mumbai. The colours obtained are as follows: brown, green, yellowish brown, red, white, dark blue, yellowish green, black, grey, maroon, orange, pink, yellow and light blue.

Detergents used: Surf Excel, Henkomatic and Genteel respectively.

Other chemicals used: AOS (α-olefine sulphonate surfactants) and water were used as standards. AOS was of analytical grade and used as such without any further purification

Evaluation of wash fastness: Results were assessed by grading against standard A04/A05 greyscales. Here samples of the fabric consisting of the given hue were matched against these grey strips. This enabled to equate the differences in lightness with differences in colour. The standard used here was a white undyed fabric.

Experimental

The fabrics were subjected to a total number of washes to study fading. This was done based on an estimated use of the garment for approximately one year with a wash every two weeks. The fastness of colour was studied using the original sample and the comparision was done using the grey-scale method.

Procedure: a) Preparation of the material: Fabrics were first cut into pieces (48x20 cm) and sixteen pieces of the different colours were machine stitched together to give ten fabric pieces of size 96x160 cm. These fabric pieces were exposed to wash conditions using a variety of detergents. The effect of the detergents on the fabric was compared using water as the standard. The number of washes for each set of fabric pieces were thirty and samples were taken after every five washes. This was based on the estimated use of a garment for approximately two years with a wash every two weeks.

b) Testing nature for washing: The procedure for washing was done as per the instructions mentioned on the packet of the detergents respectively. A material to liquor ratio (1:30) was maintained for all washes. For liquid detergents, the volume of the detergents was calculated based on the total volume of detergent solution. (Approximate $20cm^3$ for 10 L of detergent solution for all the detergents were used). For AOS, (60% by volume was used *i.e* $12cm^3$ for 10 L. For solid detergents, quantity of detergents were calculated based on the weight of the fabric (60 g of the detergents for 5 kg of the fabric). The washings were carried out by stirring for 20 min, followed by three rinses with water. Fabric was dried in between successive washes in the shade water used for washes were tested for the presence of chlorine using dil. H_2SO_4 and KI.

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The visible spectrum of the tap water being used was recorded. The pH of the wash solutions and temperature of the washings were recorded and are as follows. All water samples showed no presence of chlorine.

Serial number	Name of detergent solution	Preparation of solution		pH
		Detergent (cm^3)	Total liquor (cm^3)	
1	Water	-	-	7.02
2	AOS	0.48	400	7.98
3	Genteel	0.76	380	7.14
4	Surf excel	140 mg	350	9.7
5	Henko matic	140 mg	400	9.8

Table 1. Procedure for preparation of solution

c) Wash procedure: The stitched fabric pieces were immersed into a solution containing the detergent and were washed and dried. After every five washes the cloth was cut, weighed and then washed with the new volume/mass of detergent. This was done consistently for every thirty washes for different detergents on each of the ten pieces of the dyed fabric. After thirty washes, the fabric was observed for shade change or fading. Wash solutions for the 10 sets of wash experiments were prepared as follows.

Serial no	Wash solution	M:Lratio	Preparation of solution
1	Water		-
2	AOS	↑ **1:30** ↓	$12cm^3$ for 10 L solution
3	Genteel (Sample A)		20 $12cm^3$ for 10 L solution
4	Genteel (Sample B)		$20cm^3$ for 10 L solution
5	Surf Excel (Sample A)		60 g detergent per 5 kg fabric
6	Surf Excel (Sample B)		60 g detergent per 5 kg fabric
7	Henkomatic (Sample A)		60 g detergent per 5 kg fabric
10	Henkomatic (Sample B)		60 g detergent per 5 kg fabric

Table 2. Wash solutions used in the study

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The material to liquor ratio (M:L) was maintained at 1:30 by weighing the fabric before preparation of the solution. For liquid detergents, the volume of detergents was calculated based on total volume of wash solution (as per M:L ratio) and the instructions on the detergent bottle. For solid detergents, the weight of the detergent was calculated based on the weight of the fabric and instructions on the detergent pack. For AOS (active component in liquid detergents), 60% of volume was required. Washing was carried out by stirring the fabric in the wash solution for about 20 mins. Fabric was then rinsed three times in water and dried completely in the shade before the next wash. After every five washes a sample of (20cm x 4cm) of each colour was cut out. A total of 30 washes was performed for each of the ten experiments. The samples taken after 25 and 30 washes were examined for fading and running of colour using the grey scale. The results are as follows.

Results and discussion

The wash fastness properties of naturally dyed fabrics is considered to be one of the most important method used to characterize dye textile materials **[19-24]**. Wash fastness properties differs for different fabrics. They are dependent of the various methods of dyeing and their application. For example, wash fastness of natural dyes on cotton are relatively low. Previous literature reports states that some natural dyes showed distinctions of colours after washing the dyed textiles in the alkali presence, which strongly emphasized the need of knowing the pH of alkali solutions to clean natural dyed garments **[24]**. Natural dyes have largely been replaced by synthetic dyes as they are found to be more cost effective, have varied and better brighter colours which are found to be more suitable and wearable under different conditions **[11]**.

Here in this paper, the wash fastness property of the naturally dyed fabrics using different detergents was studied. Ambient temperature at which washings were done were recorded during each wash and the temperature range was approximately 26-32º C. Patches of the naturally dyed fabrics were subjected to washing using different detergents at a material -liquor ratio of 1:30 at RT for about an hour. After every 25^{th} and 30^{th} washing the fabrics were studied for shade change. The shade change, colour fastness and wash fastness properties of the dyed fabrics were noted. It was observed that the colour change of the naturally dyed fabrics changed when they were put through the washing process and that the washing conditions used in the colour fastness testing which caused shade changes on the dyed fabrics was without the use of any mordant. The significant shade change observed on the naturally dyed fabrics using different detergents was observed. The result of fastness property using different detergents are shown in **Tables 3-5**.

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Sr. No	Colours of the naturally dyed fabric	Surf excel			
		A (25 washes)		B (30 washes)	
		Ratings	Observation	Rating	Observation
1	Brown	3/4	SC	4	SC
2	Green	4/5	-	4/5	-
3	Yellowish brown	4		4/5	-
4	Red	3/4	SC	3/4	SC
5	White	2/3	B	2/3	B
6	Dark blue	3/4	SC	3/4	SC
7	Yellowish green	3/4	SC	3	SC
8	Black	3	SC	3	SC
9	Grey	3/4	SC	3/4	SC
10	Maroon	4/5		4	-
11	Orange	4	SC	3/4	SC
12	Pink	2/3	SC	2/3	SC
13	Yellow	4/5		3/4	SC
14	Light blue	4/5		4/5	

- **5- excellent, 4-good, 3-fair, 2-poor, 1-very poor**
- **Grade 5: no change in colour or staining**
- **Grade 1: substantially different**

Table 3:– Fastness property of naturally dyed cotton fabric (Detergent used-Surf Excel)

Sr. No	Colours of the naturally dyed fabric	Henkomatic			
		A (25 washes)		B (30 washes)	
		Ratings	Observation	Rating	Observation
1	Brown	3/5	SC	3/5	SC
2	Green	4	-	4/5	-
3	Yellowish brown	3/5	SC	3/5	SC
4	Red	3/5	-	3	SC
5	White	2/3	B	2/3	B
6	Dark blue	3/5	SC	3/5	SC
7	Yellowish green	2/3	SC	2/3	SC
8	Black	3/5	SC	3/5	SC

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9	Grey	2/3	SC	2/3	SC
10	Maroon	3	SC	4	-
11	Orange	4	-	3/5	-
12	Pink	2/3	SC	2/3	SC
13	Yellow	3/5	SC	3/5	SC
14	Light blue	3	SC	3	-

- **5- excellent, 4-good, 3-fair, 2-poor, 1-very poor**
- **Grade 5: no change in colour or staining**
- **Grade 1: substantially different**

Table 4: Fastness property of naturally dyed cotton fabric (Detergent used – Henkomatic)

Sr. No	**Colours of the naturally dyed fabric**	**Genteel**			
		A (25 washes)		**B (30 washes)**	
		Ratings	**Observation**	**Rating**	**Observation**
1	Brown	4/5	-	3/4	SC
2	Green	4/5	-	4/5	-
3	Yellowish brown	3/4	SC	3/4	SC
4	Red	4	-	3/4	SC
5	White	2/3	B	2/3	B
6	Dark blue	3/4	SC	3/4	SC
7	Yellowish green	3/4	SC	2/3	SC
8	Black	3/4	SC	4/5	-
9	Grey	3	SC	3	SC
10	Maroon	4	-	3/4	SC
11	Orange	3/4	SC	3/4	SC
12	Pink	2/3	SC	2/3	SC
13	Yellow	3	SC	3	SC
14	Light blue	4/5		4	-

- **5- excellent, 4-good, 3-fair, 2-poor, 1-very poor**
- **Grade 5: no change in colour or staining**
- **Grade 1: substantially different**

Table 5: Fastness property of naturally dyed cotton fabric (Detergent used – Genteel)

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From tables **3-5**, it was observed that the naturally dyed fabrics exhibited a good-very good fastness to washing. Most natural colours were found to show market acceptable wash fastness. It was however observed that fading was more or greater for the fabrics with the solid detergents probably due to the presence of bleaching agents in the detergents and the selectively higher pH of the solutions of the solid detergents. It was seen that fading with liquid detergents was significantly less. A slight change in shade colour on the fabrics were observed and after 5 washes, no staining was observed. Even passing through **25** and **30** washes respectively, they could still retain their colour strength and no colour fading was observed. In fact, for some colours, the shade of the dyes appeared brighter. It can therefore be elucidated that the detergents were attached firmly on the cotton material which was naturally dyed thereby bringing about a change in colour of the fabrics. More importantly, fixing the dyes with detergents gave us an insight regarding the dye-detergent relationship. That is an intense shade was developed after the fabric was brought to the fastness testing. This may be due to the instability of the dye molecules, which resulted in a change of shade and colour strength on the fabrics once the dyes were exposed to the conditions used in the fastness testing. It could also be as a result of the dye molecules which may be sensitive to the alkaline nature of the detergent solution at a particular temperature. The visible spectrum of the tap water used was runned. No significant absorption was recorded for the same. From the results, it was found that the colour fastness to washing was in a good-excellent level on the cotton fabrics. Thus it can be concluded that the wash fastness properties obtained were excellent.

Conclusion Most of the naturally dyed cotton fabrics showed remarkable wash fastness property. It was observed that fading was more or greater for the fabrics treated with the solid detergents probably due to the presence of bleaching agents in the detergents. This may be due to the selectively higher pH of the solutions of the solid detergents. On the other hand, it was noted that fading with liquid detergents was significantly less. We can thus conclude that as bleaching agents are added to solid detergents mainly to avoid formation of scum in the machine, efforts should be made to develop a liquid detergent for the washing machine having anti-fungal agents to avoid scum and odour formation in the machine. The results obtained in this work show a promising potential of the use of natural dyes practically in the textile industry where the wash fastness properties of the fabrics is retained to some extent. Moreover, natural dyes are more convenient to use as they are safe, eco-friendly and non-toxic as well as the quality control on the shade obtained can be easily achieved as compared with the synthetic dyes used in the various sectors. The washing process may cause a shade variation more or less depending the washing conditions and the types of mordant employed in the dyeing. The study investigated provided us information regarding the parameters affecting the properties of the dyes and the way how improvement could be figured out and developed so as to encourage the utilization of natural dyes for better applications in the textile industry.

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References

1. N.B. Guesmi, N. Ladharia Hamadi, F. Sakli, "Dyeing properties and colour fastness of wool dyed with indicaxanthin natural dye". Industrial Crops and Products, 37 (2012), 493–499.
2. P. Sacvarino, G. Viscardi, P. Quarliotto, E. Montoneri, and E. Barni, "Reactivity and effects of cyclodextrins in textile dyeing". Dyes and Pigments, 42 (1999), 143–147.
3. R. Prabhavathi, Dr. A. Sharada Devi & Dr. D. Anitha, "Improving the Colour Fastness of the Selected Natural Dyes on Cotton (Improving the sunlight fastness and washfastness of the eucalyptus bark dye on cotton)". IOSR Journal of Polymer and Textile Engineering, 1 (2014), 27-30
4. R. Dayal & P C. Dobhal, "Natural dyes from some Indian plants". Colourage, 48 (2001), 33-38.
5. S. V. Singh, & M C Purohit, "Evaluation of colour fastness properties of natural dye extracted from Symplocos racemosa (Lodh) on wool fibres using combination of natural and synthetic mordants". Indian Journal of Fibre & Textile Research, 39 (2014), 97-101
6. R. D. Gaur, "Traditional dye yielding plants of Uttarakhand". Natural Product Radiance, 7 (2008), 154-165.
7. D. Atalie, G. Ashagre, G. Nalankilli, "Impact of Sunlight Exposure to different Dyed fabrics on Colorfastness to Washing". International Journal of Modern Science and Technology, 2 (2017) 360-365.
8. L. Li, "Measures for color fastness to wet crocking of cotton fabric dyed with reactive dyes [J]". Dyeing and finishing, 7 (2004) 23-25.
9. H.-r. Cui, "Color fastness improvement (II) [J]". Dyeing and finishing, 22 (2004) 15-20.
10. L. Lin, Md. Z. Rahman, S. Wen, R. Navik, P. Zhang, Y. Cai, "Improvement of Colour Fastness for Deep Blue Shade of Cotton Fabric". 4th International Conference on Machinery, Materials and Computing Technology (ICMMCT 2016).
11. L.G. Angelini, A. Bertoli, S. Rolandelli, L. Pistelli, "Agronomic potential of Reseda Luteola L. as new crop for natural dyes in textiles production". Industrial Crops and Products, 17 (2003), 199-207.
12. N.A. Ibrahim, A.R. El-Gamal, M. Gouda, F. Mahrous, "A new approach for natural dyeing and functional finishing of cotton cellulose". Carbohydrate Polymers, 82 (2010), 1205-1211.
13. T. Bechtold, A. Turcanua, E. Ganglbergerb, S. Geisslerb, "Natural dyes in modern textile dyehouses: how to combine experiences of two centuries to meet the demands of the future?," Journal of Cleaner Production, 4 (2003), 499–509.

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14. T. Bechtold, A. Mahamud-Ali, R. Mussak, "Natural dyes for natural textile dyeing: A comparison of methods to assays the quality of Canadian golden rod plant material". Dyes Pigments, 75 (2007) 287–293.
15. S. Baliarsingh, A. K. Panda, J. Jena, T. Das, "Exploring sustainable technique on natural dye extraction from native plants for textile: identification of colourants, colourimetric analysis of dyed yarns and their antimicrobial evaluation". Journal of Cleaner Production, 37 (2012), 257- 264.
16. A. Barka, A. Assabbanea, A. Nounah, L. Laanab, Y.L. Ichou, "Removal of textile dyes from aqueous solutions by natural phosphate as a new adsorbent". Desalination, 235 (2009), 264–275.
17. H. Dayioglua, D. Kutb, N. Merdana, S. Canbolata, "The Effect of Dyeing Properties of Fixing Agent and Plasma Treatment on Silk Fabric Dyed with Natural Dye Extract Obtained from Sambucus Ebulus L. Plant". Procedia - Social and Behavioral Sciences, 195 (2015) 1609-1617
18. S. Sahahidi, A. Rashidi, M. Ghoranneviss, A. Anvari, J. Wiener, "Plasma effect on anti-felting properties of wool fabrics. Surface & Coatings Technology". 205 (2010) 349-354.
19. T. Bechtold, R. Mussak, Handbook of Natural Colorants, West Sussex: ENG: John Wiley and Sons, (2009) 321–322.
20. G. W. Taylor, "Natural dyes in textile applications," Review of Progress in Coloration and Related Topics, 16 (1986) 53–61.
21. Y. A. Ding, "Comparison of Mordant and Natural Dyes in Dyeing Cotton Fabrics (M.Sc-Thesis)". North Carolina State University, Raleigh, North Carolina, 2013.
22. S. Ali, N. Nisar, T. Hussain, "Dyeing properties of natural dyes extracted from Eucalyptus," The Journal of the Textile Institute, 98 (2007) 559–562.
23. R. Mongkholrattanasit, J. Krystufek, J. Wiener, J. Studnickova, "Properties of wool and cotton fabrics dyed with Eucalyptus, tannin and flavonoids," Fibers and Textiles in Eastern Europe, 19 (2011) 90–95
24. T. Rossi, M. C. Araújo, J. O. Brito, S. Harold, T W Freeman, "Wash Fastness of Textile Fibers Dyed with Natural Dye from Eucalyptus Wood Steaming Waste ". International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering, 9 (2015) 11-14