www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(9): 2667-2671

www.thepharmajournal.com
Received: 14-06-2023
Accepted: 23-07-2023

Purnima Das
M.Sc. Student, Department of Textiles and Apparel Designing, College of Community Science, Assam Agricultural University, Jorhat, Assam, India

Binita Baishya Kalita
Professor and Head, Department of Textiles and Apparel Designing, College of Community Science, Assam Agricultural University, Jorhat, Assam, India

Sunita Boruah
Assistant Professor, Department of Textiles and Apparel Designing, College of Community Science, Assam Agricultural University, Jorhat, Assam, India

Shilpi Buragohain
M.Sc. Student, Department of Textiles and Apparel Designing, College of Community Science, Assam Agricultural University, Jorhat, Assam, India

Moirangthem Jeena Devi
M.Sc. Student, Department of Textiles and Apparel Designing, College of Community Science, Assam Agricultural University, Jorhat, Assam, India

Corresponding Author:
Binita Baishya Kalita
Professor and Head, Department of Textiles and Apparel Designing, College of Community Science, Assam Agricultural University, Jorhat, Assam, India

Coconut (*Cocos nucifera*) husk: An agro-waste for surface enrichment of silk fabric

Purnima Das, Binita Baishya Kalita, Sunita Boruah, Shilpi Buragohain and Moirangthem Jeena Devi

Abstract
This investigation was concerned with dye extraction from coconut husks on mulberry silk fabric. Dyeing process was carried out keeping the material to liquor ratio 1:30 at a constant temperature of 70 ºC for 45 minutes. Silk fabrics dyed in a solution composed of coconut extract from husks showed a brown shade. The colour fastness to sunlight, washing, rubbing, pressing and perspiration after dyeing and printing the silk fabric treated with the alum and gallnut mordants was investigated, the results of which showed fair to good fastness, whereas the colour fastness to washing was at a good to very good level.

Keywords: Natural dye, coconut husks, silk, dyeing, eco-print, colourfastness properties

1. Introduction
Natural dyes are not new to Indian culture. It is an ancient skill wealthy in history and tradition. The first colours used for textiles were most likely little more than stains. India has a rich plant biodiversity which is ranked 11th as the largest biodiversity in the world and there is no doubt that the plant kingdom is a treasure-house of diverse natural products. There are several plants or parts of plants that provide natural dyes which are used in the textile industry. The plants containing dyestuffs obtained through agriculture (root dye, indigo, budgerigar etc.) are included. They are compatible with nature due to their non-hazardous nature, non-allergic, non-toxic, and produced colours that are mild, soft, subtle and create a restful effect. Many natural dyes are available from tree waste or can be easily available in the market [18, 15].
The natural dyes have finite substantively for the fiber that requires the mordant which enriches the fixation of dyes on the fiber by the formation of compound with the dyes. The word mordant comes from the Latin word "mordere", meaning "to bite" which precipitates the colour matter in a less soluble form in the fiber. During mordanting, mordant reacts with textile materials and improve their affinity for dye. Dye molecules from solution then diffuse into the fabric matrix; followed by adsorption of dye molecules at surface of fabric then absorbed into the polymer matrix of the textile materials, followed by chemical fixation of dye molecules into the mordanted fabric [9]. Mordants generally use in dyeing are aluminum potassium sulfate, iron sulfate, copper sulfate, stannous chloride, and potassium dichromate. The bio mordants such as myrobalan (*Terminalia chebula*), pomegranate rinds (*Punica granatum*), tannin, tannic acid, tartaric acid, guava, banana leaves ash, valex and rosemary are eco-friendly that provides good fastness properties. Gall nut (oak gall) used as bio-mordant containing hydrolysable tannins like gallic acid, ellagic acid and polyphenolic gallotannins to produce light yellow colour. The oak gall is an abnormal growth on oak tree (*Quercus infectoria* Oliv.) aggravated by the bite of female cynipid wasp (*Cynips Gallae-tinctoria*). Gall wasp pierce young twigs of oak tree and lays its eggs inside. The gall particles of *Q. infectoria* are grey-brown and globulous with a surface coating of solid, pointed spines, and they measure 6-10 mm in diameter [19].
Silk has been considered the superlative of all resources highly priced textile fabric, known as the 'Queen of Textiles'. Silk is a natural protein fiber that is a filament fiber produced by silkworms. The chemical composition of silk fiber is 76% of fibroin, 22% of sericin, 1.5% of Waxes and fats, 0.5% of Mineral salt. The silk fiber is known for its versatile characteristics such as strength with lightness, durability with beauty, cleanliness with lustre, excellent drape, hydrophilic and stain resistance. Some of the limitations of silk fibers are fair abrasion and resiliency, turns yellow if bleached, poor resistance to exposed sunlight and expensive.

India is the second leading silk producer in the world. The silk fiber is made up of 'sericin' and the 'fibroin' whereas fibroin is secreted by the posterior silk gland. It is a very large insoluble polypeptide that is difficult to purify from the cocoon without degradation [6].

The art of Eco printing create a visual effects through natural colorants existing in plants, flowers, insects, fruits, vegetable by products etc. natural colorant from these materials transferred to paper or fabric via steaming. It allows designers and artists to present their imaginations unrestrictedly, unpredictable results, patterns, colour, and visual effects are possible. Since flowers are obtained from nature and contain natural biodegradable colouring agents, these could be grouped as natural dyes and suitable for eco-printing [4].

2. Materials and Methods

2.1 Collection of fabric

The mulberry silk (*Bombyx mori* L.) fabrics were collected from the local market of Jorhat district of Assam.

2.2 Selection and collection of natural dyes

Coconut (*Cocos nucifera*) husks were selected for the study as a natural dye and collected from the local market of Jorhat district, Assam.

2.3 Selection and collection of mordants

Natural mordants gallnut was selected for the study based on the pre-testing results and collected from online shopping. Metallic mordant alum was used for the study.

2.4 Preparation of coconut husk

The coconut husk was collected from the market and cleaned with water. After that coconut husks were cut into small pieces using a sharp knife and dried under sunlight. After the process of drying, an electrically operated high-efficiency grinder machine was used to grind the husk to form a dye powder.

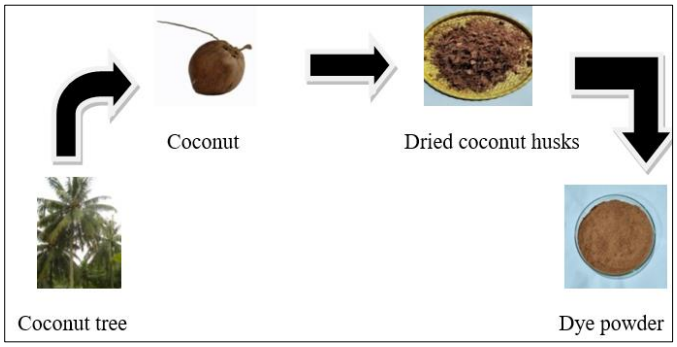

Fig 1: Preparation of coconut husks dye powder

2.5 Preparation of natural mordant

The natural mordant gallnut was ground in a mortar and pestle and converted to powder form. `

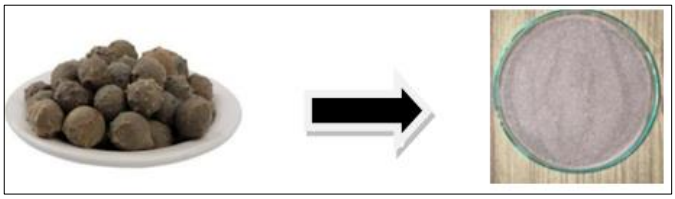

Fig 2: Gallnut mordant

2.6 Preparation of mulberry silk fabric

Degumming

Degumming is a process of removing sericin, or silk gum from silk fabric. Mulberry silk fabrics were weight accurately and a required amount of water was taken. The silk fabric was boiled in a 5 g/liter of washing soda was mixed into the liquor at 60 °C for 35 minutes. After 35 minutes, the fabric was taken out from the liquor and thoroughly washed out under running water. The fabric was dried in shades at room temperature.

2.7 Extraction of dye for silk fabric

Aqueous dye solution was prepared, by adding 4 gm of Coconut husks in 100 ml of distilled water at 100 °C for 75 minutes. Then the extracted dye liquor was filtered through a sieve and filter paper. The optical density of dye liquor was recorded.

2.8 Dyeing of mulberry silk fabric

The silk fabric was dyed with a material-to-liquor ratio of 1:30 at a constant temperature of 70 ºC for 45 minutes followed by rinsing with running water and dried in the shade. Mordants were used in the dyeing process to assist in the absorption and fixation of dye molecules between the silk fibers. The optical densities before and after dyeing were recorded.

2.9 Mordanting method used

Pre-mordanting method

In the pre-mordanting dyeing method, the fabric was mordanted first and then dyed. An aqueous solution was prepared by adding the 2 g of alum and 1 g of gallnut mordant in water. The fabrics were boiled in this solution for 30 minutes at 70 ºC for both the mordants and after that, the fabric was transferred to the dye bath for dyeing.

2.10 Eco-printing process

In the eco-printing method, different leaves with varieties of shapes and good definitions of the veins were selected. The leaves were thick enough so that it does not melt completely under heat. The top sides of the leaves are called the sun side and the bottom sides are called the moon side. It is ideal to place the leaf on the moon side in contact with the target fabric. Target fabric is the fabric in which the eco-printing is to be done. Blanket fabric is the fabric that is used to put on top of the target fabric with leaves sandwiched in the middle and placed in a steamer for a period of 2 hours. After that, the fabric was allowed to cool down completely and then open the package.

Plate 1: Different colour shades of dyed and eco-printed mulberry silk fabrics

2.11 Evaluation of colour fastness properties of dyed and eco-printed silk fabrics

All the dyed and eco-printed mulberry silk fabric samples were evaluated for colour fastness to sunlight, washing, crocking or rubbing (dry and wet), pressing (dry and wet) and perspiration (acidic and alkaline) by using AATCC (1968) method.

Interpretation of results of the colour fastness test

With the help of ASTM (1968) [3] greyscale, the test specimens were assessed to evaluate the colour change (CC) and colour staining (CS). The following grades of colour change and staining were indicated by the numerical rating of two adjacent fabrics staining as specified in the grey scale.

Table 1: Evaluation of Colour Change (CC) and Colour Staining (CS) Ratings

Grade	Colour Change	Colour stained
1	Very good	Negligible or no staining
2	Good	Slightly stained
3	Very fair	Noticeable stained
4	Fair	Considerably stained
5	Poor	Heavily stained

3. Results and Discussions

3.1 Colour fastness to sunlight

All the dyed and eco-printed samples were tested against the colour fastness sunlight and presented in Table 2. It was interesting to note that the gallnut mordanted fabric showed very good colour fastness to sunlight while without mordanted, alum mordanted and eco-printed with gallnut mordanted fabric exhibited good colour fastness to sunlight. However, eco-printed with alum mordanted fabric sample depicted very fair fastness property to sunlight. The light fastness result indicates that the use of a mordant was advantageous for silk fabric dyed with coconut husk dye. All the dyed silk fabrics were faded more except gallnut mordanted fabric. This could be attributed to stripping of colouring component from fabric into dye bath. This formed insoluble coloured complex in dye bath and rendered non-available to fabric. Furthermore, the possible structure of mordant and dye molecules that influenced the colour fastness properties of light. The results were supported by the study conducted by Mahale and Naikwadi, (2019) [14] found that the fading may be due to with short wavelength with high energy leads to breakdown in the light energy absorption capacity of the electrons of the chromophores or a breakdown in the structure of the dye molecules. When sunlight energy is absorbed, the loosely held electrons of the chromophores are raised to higher level *i.e.*, that become more active.

3.2 Colour fastness to washing

Wash fastness of dye is influenced by the rate of diffusion of dye and the state of dye inside the fiber [2].The data of dyed and eco-printed fabrics against colour fastness to washing were evaluated using grey scale and depicted in Table 2 that all the dyed, mordanted and eco-printed with mordanted samples exhibited very good fastness to washing and colour change. This may be due to that extracted dye had direct affinity for protein fiber and may be due to the tannin used in dyeing and eco-printing process. No colour stained was observed in dyed sample without mordanted and gallnut mordanted fabric samples. On the other hand, alum mordanted, eco-printed with alum and gallnut mordanted sample showed slightly stained. The stain observed in the sample may be due to the presence of loose dye molecule on the surface of the fabric during the rinsing process after dyeing. Moreover, this may be also resulted of saturated

condition of fiber molecule that cannot absorb the extra molecule present in the dye bath. Similar observations were also agreed with Kundal *et al.* (2016) [13]. It is found that low percentage of metallic mordant using in silk dyeing may not made a firm stable complex with silk fabric and during washing easily washed the mordants from fabric surface [11]. Some of the natural dyes undergo a little change in their hue on washing; this may be due the alkaline nature of the washing mixture mainly the pH. Generally, the fastness of a colour can vary with the type of dye, the shade used, the depth of colour as well as the dyeing process and mainly the nature of the washing combination [16].

3.3 Colour fastness to crocking (dry and wet)

The evaluated results were presented in the Table 2. The results revealed that without mordanted and alum mordanted fabrics showed very good colour fastness and no colour stained was found in without mordanted, alum mordanted and gallnut mordanted in dry crocking. Additionally, in wet crocking, without mordanted showed very good colour fastness and negligible stained. Good and slightly stained was occurred in mordanted dyed and eco-printed silk fabric samples. This may be due to the presence of loose dye molecule on the surface of the fabric which was not wash out properly during rinsing process. Generally, most of the natural dyes are found to be moderate to good rubbing fastness and does not require any after treatment [17]. A similar observation was also found by Tayade and Adivarekar, (2013) [20]. Kumaresan *et al.* (2011) [13] evaluated the colour fastness to rubbing (dry and wet) of silk dyed with an extract of *Cordia sebestena*. Ado *et al.* (2014) [2] reported that they found an excellent fastness to rubbing. However, the colour fastness of natural dyes not only depends on chemical nature and type of colourant, but types of mordant being used on chemical nature and the combination of fiber mordanted to achieve best colour fastness. The result was on per with Hosen *et al.* (2021) [8] reported that, the dry rubbing fastness properties was very good for Colocasia and lemon mordanting sample while very fair was observed in mordanting with potash alum. Jahan and Datta, (2015) [10] found more or less similar ratings on a comparative study on dyeing of cotton and silk fabric using madder as a natural dye.

3.4 Colour fastness to pressing

The colour fastness properties of all treated samples were evaluated, and results are shown in Table 2. From the result highlighted in Table 2 inferred that the fabric treated with dyed, mordanted and eco-printed with alum as well as gallnut exhibited very good fastness and no stain in dry pressing. This may be due to the uniformly deposition of dye and mordant molecules into the fabric surface. It is interesting to note that in wet pressing dyed, mordanted and eco-printed with mordanted fabrics showed good to very good fastness and no colour stain was obtained in dyed with and without mordanted fabric. The slightly stained observed in mordanted eco-printed fabrics may be due to the deposition of loose dye molecule on the surface of the fabric. Bhuyan and Gogoi, (2013) [5]; Jabar *et al.* (2020) [9] were found comparable outcomes on the value addition of Eri silk yarns with *Datura stramonium* and colour fastness properties of mordanted *Bridelia ferruginea* B. dye was extracted from the bark of the tree using aqueous extraction method in cellulosic fabric. Gogoi, (2022) [7] also depicted the similar observations on utilization of eucalyptus bark extracted for dyeing of silk with Banana pseudo stem as a natural mordant.

3.5 Colour fastness to perspiration (acidic and alkaline)

Colour fastness to perspiration test is used to determine the resistance of the colour of textile of all kinds and in all forms to perspiration. Colour fastness of all samples against perspiration in both acidic and alkaline mediums was assessed, and value was registered in Table 2. A good to very good result was observed in dyed and eco-printed silk fabrics against colour fastness to perspiration for both acidic and alkaline medium. The reason may be due to the affinity of dye extract towards the silk fabric and uniformly set down on the inner space of the fabric as well as fiber molecule. On the other hand, colour fastness to perspiration rating showed slightly stained attributed to both acidic and alkaline conditions against dyed as well as eco-printed fabrics. It may be due to the mordant and mordanting methods used, mordant created a bond between dye molecules and fabric that remained on the surface. Jabar *et al.* (2020) [9]; Jahan and Datta, (2015) [10] found comparable outcomes on the colour fastness properties of mordanted *Bridelia ferruginea* B. dyed cellulosic fabric and a comparative study on dyeing of cotton and silk fabric using madder as a natural dye.

Table 2: Ratings for colourfastness properties of dyed and eco-printed fabric samples

S. No.	Fabric samples	Sunlight	Washing		Crocking				Pressing				Perspiration			
					Dry		Wet		Dry		Wet		Acidic		Alkaline	
		CC	CC	CS	CC	CS	CC	CS	CC	CS	CC	CS	CC	CS	CC	CS
1	Without mordanted	4	5	5	5	5	5	5	5	5	5	5	5	5	5	4
2	Alum mordanted	4	5	4	5	5	4	4	5	5	5	5	4	4	4	4
3	Gallnut mordanted	5	5	5	4	5	4	4	5	5	5	5	4	4	4	4
4	Eco-printed (alum)	3	5	4	4	4	4	4	5	5	4	4	4	4	4	4
5	Eco-printed (gallnut)	4	5	4	4	4	4	4	5	5	4	4	4	4	4	4

CC: Colour Change CS: Colour Staining

CC Ratings: 1= poor, 2= fair, 3= very fair, 4=good, 6= very good

CS Ratings: 1= heavily stained, 2= considerably stained, 3= noticeable stained, 4= slightly stained, 5= negligible or no staining.

4. Conclusion

Recently, the application of natural dyes is increasing worldwide, as they are environment friendly. The dye exhibited good affinity to colour textile substrate and the dyed silk fabrics showed good fastness properties in addition to UV protection and anti-microbial properties. The good colour fastness properties of silk fabrics dyed with coconut husk extract is attributed to the fact that these dyes contain tannin, which may help in covalent bond formation with the fiber, thereby resulting in good fixation on the fibrous material. Furthermore, these tannins having a phenolic formation can form metal chelation with different mordants. Since these tannins are insoluble in water, eventually improving the washing fastness. Mordanting enhances tint and fastness

properties of natural dyed silk fabric. Pre mordanting dyeing method produces deepest hue than the other methods. Therefore, there is a tremendous scope to use coconut husk dye for obtaining various hues using mordants under eco-friendly textile dyeing.

5. References

1. AATCC. AATCC Technical Manual 1967, American Association of Textile Chemist and Colorist, New York. 1968;25:619-639.
2. Ado A, Yahaya H, Kwalli AA, Abdulkadir RS. Dyeing of textiles with eco-friendly natural dyes: A review. International Journal of Environmental Monitoring and Protection. 2014;1(5):76-81.
3. ASTM. Standard test methods for breaking load (strength) elongation of yarn by single strandmethods. Part 24, American Society for Testing Materials, Philadelphia; c1968. p. 444-450.
4. Batham M, Mandhary S. Recycling floral waste from temple using different techniques of eco-printing on cotton fabric; c2023.
5. Bhuyan S, Gogoi N. Value addition of Eri silk yarns with Datura stramonium-A natural colourant. Journal of Academia and Industrial Research. 2013;1(9):530-532.
6. Foppiani JA, Weidman A, Alvarez AH, Valentine L, Devi K, Kaplan DL, *et al*. Clinical Use of Non-Suture Silk-Containing Products: A Systematic Review. Biomimetics. 2023;8(1):45.
7. Gogoi P. Eco-friendly Utilization of Eucalyptus Bark Extracted for Dyeing of Silk with Natural Mordant. M.Sc. Thesis, Assam Agricultural University, Jorhat; c2022. p. 13.
8. Hosen MD, Rabbi MF, Raihan MA, Al Mamun MA. Effect of turmeric dye and biomordants on knitted cotton fabric coloration: A promising alternative to metallic mordanting. Cleaner Engineering and Technology. 2021;3:100124.
9. Jabar JM, Ogunmokun AI, Taleat TAA. Color and fastness properties of mordanted Brideliaferruginea B dyed cellulosic fabric. Fashion and Textiles. 2020;7:1-13.
10. Jahan N, Datta E. A comparative study on dyeing of cotton and silk fabric using madder as a natural dye. IOSR J. Poly. Text. Eng. 2015;2:5-9.
11. Kashyap R, Sharma N, Sharma L. Dyeing of cotton with natural dye extract from coconut husk. International Journal of Science Technology and Engineering. 2016;3(4):92-95.
12. Kumeresan M, Palani PN, Kumar PE. Application of Eco-Friendly natural Dyes on Silk Using Combination of Mordants; Int. J Chem. Res. 2011;2(1):11-14.
13. Kundal JSVS, Singh SV, Purohit MC. Extraction of natural dye from Ficus cunia and dyeing of polyester cotton and wool fabric using different mordants, with evaluation of colour fastness properties. Natural Products Chemistry and Research. 2016;4(3):1-6.
14. Mahale G, Naikwadi S. Effect of acid dyes on colour fastness properties of silk fabric. The Pharma Innovation. 2019;8(10):169-172.
15. Mahela G, Sakshmi RK, Sunanda. Red Sander-A dye source for cotton. *Textile Trends* XLVIX; c2006.
16. Prabhu KH, Bhute AS. Plant based natural dyes and mordants: A Review. Journal of Natural Product and Plant Resources. 2012;2(6):649-664.
17. Samanta AK, Agarwal P. Application of Natural Dyes on Textiles, Ind. J Fibre and Text Res. 2009;34:384-399.
18. Sangeetha K, Gomathi R, Bhuvaneshwari M. Dyeing of silk fabric using lemon leaves extract with the effect of different mordants. International Journal of Innovative Research in Science, Engineering and Technology. 2015;4(6):4692-97.
19. Shahid M, Ahmad A, Yusuf M, Khan MI, Khan SA, Manzoor N, *et al*. Dyeing, fastness and antimicrobial properties of woolen yarns dyed with gallnut (*Quercus infectoria* Oliv.) extract. Dyes and Pigments. 2012;95(1):53-61.
20. Tayade PB, Adivarekar RV. Dyeing of silk fabric with *Cuminum cyminum* L as a source of natural dye. International Journal of Chem. Tech. Research. 2013;5(2):699-706.