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Natural Dyeing of 3 Different Grades of Silk Yarns Using *Musa acuminate* and Analysing of Dyed Silk Yarn by Colourfastness, Spectrophotometer & FTIR

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ABSTRACT
The natural dyeing of silk yarn and an investigation of its characteristics are the main topics of this work. Natural yarns are renewable, sustainable, biodegradable, and biorefinery, making them environmentally benign. One of the earliest natural animal protein fibres, silk thread is derived from the cocoons of silkworms and is widely used in textiles. Silk strands, which are used to make fabrics, are known for their tensile strength and glossy qualities. This test's objective is to ascertain the chosen silk yarns' quality, strength, durability, air flow, and covalent chemical bonding throughout the yarn stage. The classified silk yarns are then put through spectrophotometer and FTIR analysis tests to determine their colourfastness.
Keywords: *silk yarns, natural dyeing, colourfastness, spectrophotometer, FTIR.*

1 INTRODUCTION

Silk is a naturally occurring fibre that has been used for generations in clothing and personal apparel because it is hypoallergenic, antibacterial, and thermo regulating. There are numerous qualities and classes that these silks fall under. 100% silk yarns, which are categorised as animal-based, are made from the cocoons that silkworms weave. The silkworm's laboriously created thread is meticulously unravelled in factories using sophisticated machinery. Ultimately, every cocoon is the size of one silk thread. One of the low-tech, non-toxic methods of textile dyeing is natural dyeing, which is a biorefinery. Natural dyes can contribute to the creation of a soothing and healing environment because they are kinder and safer for our skin [9]. The ability of textile colours to withstand particular conditions is assessed using a colourfastness test. This includes tests against perspiration, water, light, rubbing, and washing. It aids in due diligence and is a crucial indicator for gauging the longevity of dyed goods. The capacity of a cloth to maintain its original colour under various mechanical, chemical, and environmental stresses is known as colourfastness. It mostly indicates that the fabric can withstand numerous washings without fading, bleeding, or undergoing other unfavourable changes. The resistance of a substance to alter any of its colour properties, to colourants transferring to nearby materials, or to both is known as colour fastness. When a colour fades, it lightens and alters. The transfer of colour to a secondary, adjacent fibre substance is known as bleeding. As textiles depend on colour consistency to entice wearers, it is essential to maintain the same colour values throughout each production cycle. Measure these materials with a spectrophotometer, which determines colour spaces based on how the human eye perceives them using advanced optical technologies. For both organic and inorganic samples, FTIR provides both quantitative and qualitative examination. Chemical bonding in fibre are detected by Fourier Transform Infrared Spectroscopy (FTIR). We can determine the fiber's name by using FTIR. This method allows us to determine the precise fibre content. Both organic and inorganic molecules can be analysed using FTIR, which is extensively utilised in numerous industries. It can verify the makeup of gases, liquids, and solids. The primary application of FTIR is the identification of unknown substances.

2 MATERIALS & METHODOLOY

Name	Botanical name	Appearance	Dye	Shade
Banana Flower outer shell	*Musa acuminata*			Shades of violet
Barberry wood + Butterfly pea flower	*Berberis vulgaris L.* + *Clitoria ternatea L.*	 + 		Shades of green

Table 1

2.1 Dye extract

Collection: The Banana flower's (table 1, figure 1) outer core is used to prepare the dye powder called *Musa* burgundy. The banana flower's outer shell was collected in mass quantity from vegetable market in Chennai. The family name of *Musa acuminata* is 'Musaceae'. (table 1, figure 2) is the barberry wood *Berberis vulgaris L.* and (table 1, figure 3) is Butterfly pea flower *Clitoria ternatea L.* used to extract the dyeing substance.
Drying: The collected outer shell of banana flower, barberry bark and butterfly pea flower is washed completely and made to parched in room temperature (shade dried) until it dries completely.
Extraction of dye: The dried banana flower shell was combined and crushed into powder and filtered to get the purest form of Banana Flower outer shell (*Musa acuminata*) dye powder (as shown in table 1 figure 4) to get shades of violets. The barberry wood and butterfly pea flower is add together and crushed into powder and filtered to get the dye powder (as shown in table 1 figure 5) which gives shades of green.

2.2 Pre treatment

The pre treatment process of silk yarns are degumming process to whiten the yarns so the dyeing of yarns gets the shade of colour that expected. The degumming process was done using soap-nut (Boondhi Kottai) and wood ash water. The soap-nut paste and ash water were mixed together which gives thick water. Yarns and soaked in the boiling water of mixture in 95°C and made to boil for about ten minutes which removed all the impurities from the yarns.

2.3 Dyeing

Dyeing process: The degummed yarns of 3 different grades yarns are washed in water to wet thoroughly, the dye (*musa* burgundy) is boiled in water at 70°C, in dye bath Na_2Co_3 and ash water is added as a mordanting agent as they act an electrolyte while dyeing. The dyeing process is carried for about 45 minutes. The yarns are immersed completely and rotated evenly at intervals for the even dyeing of silk yarns.
Washing & Drying: The dyed yarns are washed for 3 times in 2 different methods. The first 2 washes is carried using normal water and the final wash in lemon juice mixed with water to retain the lustrous and

the colour of the dyed silk yarns. Finally the dyed and washed different grades of silk yarns are made to hang dry in shade until the yarns are dried completely.

Figure 1: (a) silk yarn dyeing using barberry wood and butterfly pea flower dye.
(b) silk yarns dyeing using banana flower outer shell dye.

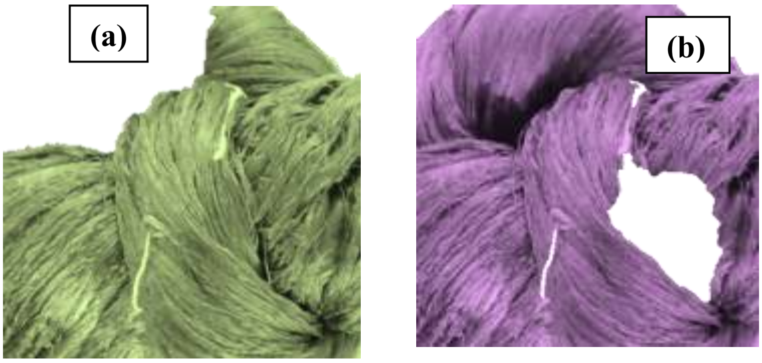


Figure2: (a) Barberry wood and butterfly pea flower dyed silk yarn
(b) Banana flower outer shell dyed silk yarn]

2.4 Colourfastness

The ability of textile colours to withstand particular conditions is assessed using a colourfastness test. Dry Rub and Wet Rub tests are used to test for colour fastness. In both dry and wet situations, the tests are performed to determine colour fastness against rubbing. Printed fabrics are tested with rotary crockmeters. One of the most crucial characteristics of textiles is colourfastness, which refers to the fabric's capacity to retain its basic colour. It is a feature of a colourant that enables it to maintain its various qualities in spite of deterioration circumstances like light exposure and dry cleaning [11]. A test known as the "rubbing colour fastness test" involves rubbing coloured samples with dry and wet rubbing yarn, respectively, and then assessing how stained the rubbing yarn is. Five levels are assigned to the test results, with five being better and one being worse. Working concept: A device known as a crockmeter, which operates on the abrasion principle, can be used to measure the rubbing colourfastness. Colour transfer from the coloured specimen to the white crocking cloth occurs when the crockmeter finger with test fabric slides across the specimen as a result of friction. The deep-dyed fibres split into tiny fibrils as a result of the abrasion and adhere to the crocking cloth indefinitely. Both damp and dry environments can cause rubbing.

Figure 3: Colourfastness tester

2.5 Spectrophotometer

The intensity of a light beam at a variety of diffident wavelengths can be measured by devices known as spectrophotometers. They are mostly used to record and evaluate colour, and they give producers an easy way to ensure that the hues they use meet their requirements and remain consistent.

Figure 4: Spectrophotometer

2.6 FTIR

FTIR spectroscopy, also known as Fourier Transform Infrared (FTIR) analysis, is sometimes used to describe inorganic materials. Infrared light is used in the FTIR test to scan samples and examine bond characteristics. Covalent bonds in molecules will selectively absorb certain wavelengths of radiation, changing the bond's vibrational energy [10]. The atoms in the bond determine the kind of vibration that the infrared light causes. The sample is positioned in a holder in the IR source's path. The analogue signal is read by a detector, which then transforms it into a spectrum. The signals are analysed by a computer to determine the peaks. After passing through a partially silvered mirror, an infrared beam is divided into two equal-intensity beams. FTIR analysis. Organic and polymeric materials are identified using this infrared spectroscopy technique.

3 RESULT & DISCUSSION

Colourfastness, spectrophotometer, and FTIR analysis are used to test the three distinct properties of silk yarns. The spectrophotometer is used to measure the quantity of colour remaining in solution at regular intervals and to identify dye stains in the colourfastness test. and to determine the chemical composition.

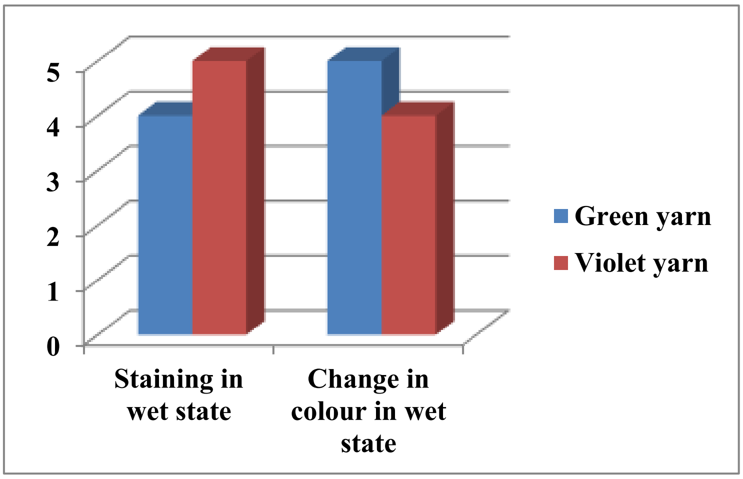
3.1 Colourfastness

A) Staining in Wet state – 50 times in crockmeter
   Green yarn – 4; Violet yarn – 5
B) Change in colour in Wet state – 50 times in crockmeter
   Green yarn – 5; Violet yarn – 4

The samples are tested in colourfastness grey scale to define the dye bleed from the fabric when it is tested in crockmeter.

Sample type	Green yarn	Violet yarn
Staining in wet state	4	5
Change in colour in wet state	5	4

Table 2



Graph 1

Thus, from the above graph shows the 2 yarns tested with colourfastness is good in both the staining and change in colour in wet state.

3.2 Spectrophotometer

The optical properties of the materials are utilised to obtain colour information using instruments known as spectrophotometers. It is the first prototype, portable, affordable, and a replacement for the desktop spectrophotometer device we have been using. The prototype model for the textile sector can identify the colour tone of any fabric. The prototype model consists of the processor, optic sensor, and display floors. Depending on the colour supplied to it, the optic sensor produces distinct frequency information on its output at that colour value (Veysel & Bocekci, 2017).

Colorant Strength Calculation

Illum: D65, WL(nm) = INT, Obs: 10 Deg, Mode: Reflectance, Spectro:5100H (YRLII)

3.2.1 Strength

Strength	Green yarn	Violet yarn
In % age	100.000	45.528
In parts	100.000	219.646
K/S	133.002	60.553
RFL	3.678	12.759

Table 3 3.2.2 Brightness Index

Yarn type	X	Y	Z	Brightness Index
Green yarn	7.585	8.487	5.035	4.007
Violet yarn	11365	10.487	14.668	12.580

Table 43.2.3 Whiteness Index

Yarn type	X	Y	Z	Whiteness Index
Green yarn	7.377	8.277	4.498	-8.137
Violet yarn	10.869	10.555	13.368	-7.858

Table 5 3.2.4 Yellowness Index

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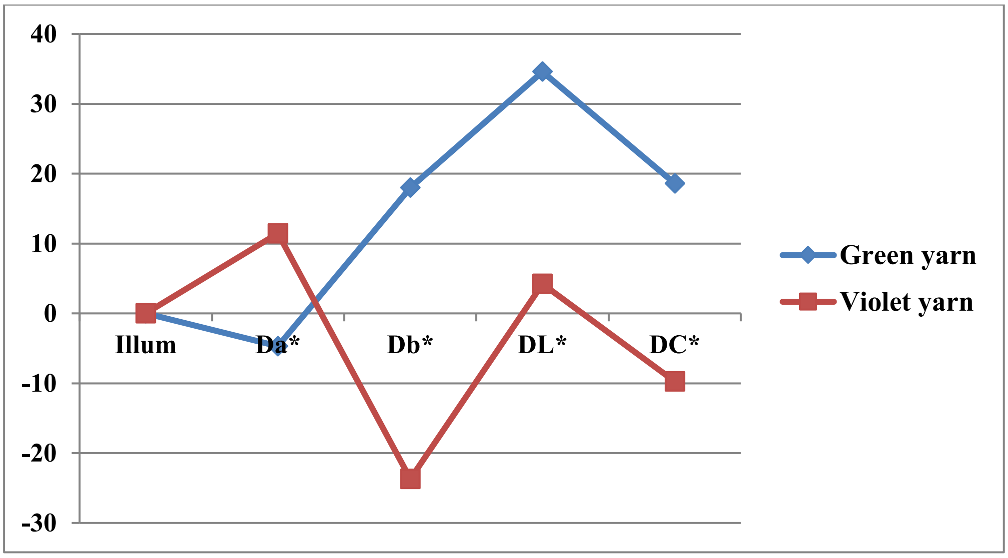
Yarn type	X	Y	Z	Yellowness Index
Green yarn	7.585	8.487	5.035	15.265
Violet yarn	11.365	10.487	14.668	-9.841

Table 63.2.5 Colour on screen

Figure 5 3.2.6 Color Difference report

Yarn type	Illum	Da*	Db*	DL*	DC*
Green yarn	D65	-4.696 (Less Green)	17.984 (Less Yellow)	34.588 (Darker)	18.587 (Brighter)
Violet yarn	D65	11.455 (Redder)	-23.697 (Bluer)	4.228 (Lighter)	-9.737 (Duller)

Table 7



Graph 2

Thus, graph 2 shows that 2 yarns dyed with natural dyes of green and violet colours shows the result of dyes infused into the silk yarns.

3.3 FTIR

The Fourier Transform The covalent and chemical linkages found in the cloth are visible using infrared spectroscopy. The functional chemical group covered across the surface of the naturally dyed silk fabric was predicted using FTIR spectra analysis. The FTIR spectra of samples of naturally dyed silk yarn are displayed in figures 3 and 4, respectively. The chemical groups were created as a result of natural dyes and cellulose-structured natural fibroin silk fabric forming chemical bonds.

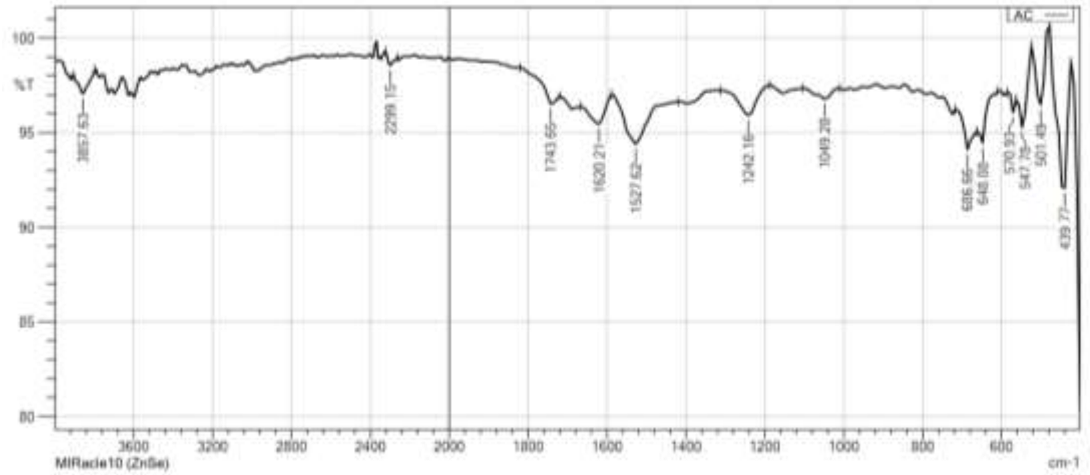


Figure 7: Green yarn

Figure 6 shows the following bonds of chemical in green dyed silk yarn such as C==CH_2 stretching (3857 cm^{-1}), N–H stretching (2299 cm^{-1}), C==C aldehyde/ketone stretching (1743cm^{-1}), C==C stretching (1620 cm^{-1}), C==C aromatic stretching (1527 cm^{-1}), below 1500 all peaks are considered as fingerprints.

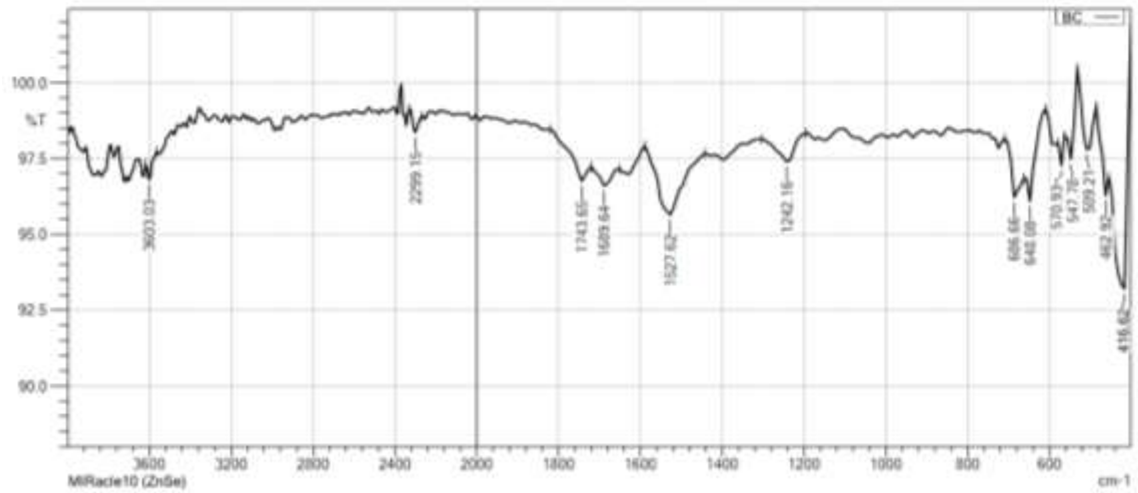


Figure 7: Violet yarn

Figure 7 shows the following bonds of chemical in violet dyed silk yarn such as O–H stretching (3603 cm^{-1}), N–H stretching (2299 cm^{-1}), C==C aldehyde/ketone stretching (1743cm^{-1}), C=O stretching (1689 cm^{-1}), C==C aromatic stretching (1527 cm^{-1}), below 1500 all peaks are considered as fingerprints.

4 CONCLUSION

The goal of this project was to use natural dyes with long-lasting properties to create environmentally friendly textile fabric. The natural dyes used to dye the silk strands are taken from natural sources and tested using FTIR, spectrophotometers, and colourfastness. Since the fabric does not readily bleed colour, the colourfastness test yields positive findings for both staining and colour change in a wet state. In a wet state, the dye that is taken from a natural source bounces well and does not colour bleed easily. Spectrophotometers use sophisticated optical technologies to measure these materials and determine colour spaces based on how the human eye interprets them. It demonstrates how beautifully natural dyes are used to dye fibres and how the colours are completely incorporated. The covalent and chemical linkages in the dyed silk fabric are shown by FTIR analysis. It demonstrates the fabric's resilience and sustainability, as well as its biodegradability and environmental friendliness for both the person and the environment. Therefore, it can be said that the silk fabric that has been naturally dyed has the potential to be used for any textile that is comfortable to wear.

References

1) https://mayfairsilk.com/pages/grades-of-silk
2) Mazharul Islam Kiron, December 1, 2013, "Factors Affecting the Rubbing Fastness of Textile Materials", Textillearner.net
3) Saniya A, Dr R Divya, Sharmila M, November 2023, "Examining the relation between the air permeability of rib knitted and thermal knitted fabrics" International Research Journal of Modernization in Engineering Technology and Science, Vol 5, Issue 11, ISSN: 2582-5208, pg: 1839-1843.
4) Dr. K M Pachiyappan, Dr. R Divya and Dr. M Kantharaj "A study on fiber size and cross-sectional shape on moisture transmission properties of knitted active sportswear", Emerging Technologies and innovative research (JETIR), Volume-6, Issue – 1, ISSN: 2349-5162.
5) https://www.jamesheal.com/articles/simple-guide-air-permeability-testing.
6) 2015, "Natural dyes: their past, present, future and sustainability", Research Development in Fibrous Material Science.
7) https://filloryyarn.com/blogs/news/what-is-silk-yarn-a-complete guide#:~:text=100%20%25%20Silk%20Yarns%20fall%20into,one%20strand%20of%20silk%20thread.
8) Sharmila M[1], Dr R Divya[2], May 2023, "Yarn Abrasion Property Test of Different Qualities and Grades of Silk Yarns" Journal of Emerging Technologies and Innovative Research, ISSN: 2349-5162, Vol 10, Issue 5, Pg: k483-k490.
9) Dr. R. Divya, 2020/5/20, "A study on natural dyeing of bamboo fiber materials using alkanna tinctoria", International Journal of Science and Research.
10) Warren Gallagher, "FTIR Analysis of Protein Structure".
11) Young-Hee Lee and Han-Do kim, October 1, 2004, "Dyeing properties and Colour Fastness of Cotton and Silk Fabrics Dyed with *Cassia tora L.* Extract", Fibers and Polymers, Vol.5, No.4, 303-308.
12) A.V. Kulichenko, 2005, "Theoretical Analysis, Calculation, and Prediction of the Air Permeability of Textiles", Fibre Chemistry, Vol.37, No.5, 371-380, 0015-0541/05/3705-0371.
13) Richard E. Marsh, Robert B. Corey, Linus Pauling, 1955, "An investigation of the structure of silk fibroin", Biochimica et Biophysica Acta, Vol.16, Pg:1-34.
14) Maria Zarkogianni, Eleni Mikropoulou, Evangelia Varella and Eforia Tsatsaroni, 27 August 2010, "Colour and fastness of natural dyes: revival of traditional dyeing techniques", Coloration Technology, pg: 18-27, doi: 10.1111/j.1478-4408.2010.00273.x
15) https://fibercurious.com/natural-dyeing/
16) Böcekçi, V. G., & Yıldız, K. (2017, September). Hand-held spectrophotometer design for textile fabrics. In AIP Conference Proceedings (Vol. 1884, No. 1). AIP Publishing.

DECLARATIONS

Ethical Approval

Not applicable

Competing interests

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