Faculty of Engineering
Department of Textile Engineering

Project (Thesis) Report on

Study on Dyeing of Cotton Knitted Fabric by Natural Dyes Extraction from Dragon Fruit (Hylocereus polyrhizus)

Course Code: TE 4214 **Course Title: Project (Thesis)**

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A thesis submitted in partial fulfillment of the requirements for the degree of
"Bachelor of Science in Textile Engineering"
Advances in Wet Processing Technology

DECLARATION

We, therefore, declare that we have completed this assignment under the **supervision of Md. Kamrul Islam, Lecturer, Department of Textile Engineering, Faculty of Engineering, Daffodil International University**. We further declare that neither this assignment nor any portion of this project has been submitted anywhere for the grant of any degree or certificate.

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LETTER OF APPROVAL

This Project (Thesis) report has been prepared by **Mahamudul Hassan Surid (ID: 201-23-817), Sharmin Sultana Mim (ID: 201-23-827) & Afsana Akter Meem (ID: 201-23-864)** have been partially approved to meet the requirements for the degree of **Bachelor of Science in Textile Engineering**. The mentioned students have completed their Project (Thesis) work under my supervision. During the research I found them sincere, hardworking, and enthusiastic

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ABSTRACT

The purpose of this study is to determine whether using natural dyes made from dragon fruit (Hylocereus polyrhizus) to dye knitted cotton fabric is both feasible and effective. The use of plant-based dyes provides an environmentally beneficial substitute for traditional synthetic dyes, particularly since the textile industry places an increasing emphasis on sustainable practices. The process of the research entails removing the colorants from the inside of the dragon fruit and assessing how well they dye knit cotton fabric. To maximize the color fastness and vibrancy of the dyed fabrics, the study investigates some dyeing parameters, such as dye concentration, mordanting methods, and dyeing time. The study also looks into the possible environmental advantages of employing natural colors, such as lower energy and water pollution levels when compared to synthetic dyes. In this study, Natural dyes have been extracted from recently famous fruit sources namely Dragon Fruit (Hylocereus polyrhizus) to dye cotton fabric using different mordants like Tannic acid ($C_{76}H_{52}O_{46}$) which is extracted from tea leaf, vinegar from the local market also commercial mordant Potassium aluminum sulfate and Ferrous sulfate at different pH mediums. It was found that different pH mediums and mordants were responsible for various shades from dark to light during colorimetric evaluation. As a result, cotton fabric can be colored with the color dye derived from dragon fruit, however, the exact shade may not always be achieved. While testing dyed fabric's fastness (wash, rubbing) properties, surface color was affected by washing, and rest fastness properties ranged around moderate. To create natural dyes that will be more ecologically friendly and sustainable in the future, the study intends to support the adoption of eco-friendly techniques in the textile production industry. It also promotes the use of agricultural by-products in this regard.

Keywords- Cotton fabrics, Natural dye, Dragon fruit, Mordent, Fastness test.

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CHAPTER-1

INTRODUCTION

1.1 Introduction:

Every aspect of natural dyes, including their history, origin, chemical makeup, benefits, and drawbacks, is studies (Nigar Merdan, Seyda Eyupoglu & Mujgan Nayci Duman – 2017 : Ecological and Sustainable Natural Dyes) .Synthetic dyes have grown in popularity due to their brilliant and long-lasting hues, which can be cheaply reproduced in large amounts, making them widely employed in a variety of industries including textiles, cosmetics, and food. Synthetic dyes provide greater fastness properties compared to natural dyes and are readily available. Natural dyes are poor in fastness properties and the colors available in natural dyeing is also limited (M. Gobalakrishnan, R. Ragavendran, E. Santhosh & R. Tamilvanan – 2020: A Review on the Extraction of Natural Dye from the Tree).

However, concerns concerning the side effects of synthetic colors on human health, as some contain compounds that may cause allergies, respiratory difficulties, and even carcinogenic effects. Natural dye sources are eco-friendly and permanent in fabrics (Vinoth Kumar, R. Prabha- 2018: Extraction and analysis of natural dye). Natural colorants pose no problems in terms of waste disposal and can provide a natural finish to textiles (B. H. Patel – 2011: Natural dyes). As a result, natural dyes have started to appear as a safer and more suitable alternative to synthetic dyes. Because these dyes are non-toxic, biodegradable, and environmentally friendly, they are a preferred alternative for individuals who care about the environment. They are derived from minerals, plant extracts, and other sources. Finally, the transition to natural colors indicates a rising awareness of the necessity of using safer, more sustainable products in our daily lives. Most arise from plants due to their ease of accessibility. Roots, fruits, leaves, and bark can all be used as dye materials. Natural dyes can also be derived from certain fungi and lichens.

In this study, an alternative dye-yielding Dragon fruit was studied for its potential for obtaining natural dye. Dragon fruit is recently become famous in our country for its unique structure, color and taste. Dragon fruit is a low-calorie tropical fruit rich in fiber and antioxidants

1.2 Objectives:

Objectives of this study

- ❖ To create an extraction media and procedure that are appropriate for Dragon fruit.
- ❖ To study how different mordants affect the dyeing qualities of natural dyed cotton fabrics.

- To compare the outcomes of dyeing with different mordants.
- To define the perfect pH medium for dyeing cotton fabric with Dragon fruit.
- To evaluate the fastness properties of the natural dyed cotton fabric.
- To look into the levelness, color yield, and color coordinates of cotton fabric that has been organically colored using dragon fruit extract
- To develop a natural dyeing procedure that can be utilized on both industrial and residential levels.

CHAPTER-2

LITERATURE REVIEW

2.1 Dyeing

Dyeing is the process of applying dye to these materials to change or enhance their color. Dyeing is the process of applying dyes or pigments to textile materials such as fibres, yarns, and fabrics to get the desired color and color fastness. Usually, dyeing is done in a specially prepared solution that contains dyes and a certain chemical. The textile dyeing process is a complex process (Fritze Lindahl -1977 : Textilerne). Temperature and time are the two most important factors in influencing how dye molecules adhere to the fiber via absorption, diffusion, or bonding. Historically, nature has served as the primary source of dye, with dyes taken from animals and plants.

2.2. Dye

A colored substance that may be fastened to fabric and is often employed in solution is called a dye. The dye must be "fast" or chemically stable, which means it will not wash away with soap and water, fade when exposed to sunlight, and so on. In other terms, it is a compound having chromosphere and auxochrome groups known as a dye. The chromosphere group is responsible for dye color due to its saturation. The dye fiber response is caused by the auxochrome groups. Two thirds of all dyes are produced for use in the textile sector (Sucharita Arora -2014 : Textile Dyes: It’s Impact on Environment and its Treatment).

Category classifications for dyes are as follows:

- ❖ **Natural Dyes**
- ❖ **Synthetic Dyes**

2.2.1 NATURAL DYES

Natural dyes are obtained from plants, insects, minerals, and other natural sources, making them a more environmentally friendly alternative to synthetic colors. These natural dyes can produce a wide spectrum of colors, from earthy tones to brilliant hues, depending on the dye's source. Natural dyes work on cotton, silk, and wool (Iqbal Sanjeeda, Ansari Taiyaba – 2014 : Nature dye :The Sources and Eco-friendly use as Textile material). Natural dyes are effective on wool, silk, and cotton. Using natural dyes in the dyeing process can produce stunning colors while also helping to lessen the textile industry's environmental effects. Many individuals are turning to natural dyes as a more sustainable and ethical alternative to synthetic dyes, recognizing the value of conserving traditional dying techniques and supporting local craftsmen. By adopting natural dyes, we can produce attractive and environmentally sustainable fabrics while also honoring the rich history and culture that underpins these old dying methods.

2.2.2 History of Natural Dyes

Natural dyes evolved together with the discovery of weaving techniques in around 5000 BC. Natural dyes have been used in India for dyeing, painting, and printing since prehistoric times. The Ajanta paintings, which date back to the first century AD, were painted with natural dyes. These paintings demonstrate the usage of colorful clothes worn by men and women throughout that era. Natural colors can be classified as vegetal or animal in origin. Except for a few mineral colors, all dyes were derived from plants or animals until the later part of the nineteenth century. Coloring matter was collected from plant roots, stems, leaves, flowers, barks, and fruits, as well as certain insects and shellfish, using a complex sequence of extraction methods.

2.2.3 Dragon Fruit as a Dye Source

Dragon fruit belongs to the Cactaceae family, specifically the Cactoidea subfamily under the Cactea tribe. Many countries refer to it as "red pitaya". In Bangladesh, it is referred to as Dragon Fruit. Hylocereus polyrhizus is a fruit known for its fragrant, night-blooming blossoms, making it a popular decorative plant globally. Betalains, a type of nitrogen-containing pigment, contribute to the deep purple hue of the pulp and skin. Dragon fruit pH is 6.5. Dragon fruit, along with other natural substances like agro-biomass (leaves, seed/flower, stem, and root) and oil palm waste, is used as an adsorbent to remove colors from wastewater. Dragon fruit is used as a raw resource in various areas such as food, fishery, dye-sensitized solar cells, and cosmetics. Using juice concentrate as opposed to the water extraction method was the most effective way to extract fruit pulp (O. Rebecca, K. V. Harivaindaran, A. N. Boyce, S. Chandran-2010 : Potential natural dye with antioxidant properties from red dragon fruit (Hylocereus polyrhizus).

Figure 2.1: Red Dragon fruit

(15.87%), α-amyrin (13.90%), octacosane (12.2%), γ-sitosterol (9.35%), octadecane (6.27%), 1-tetracosanol (5.19%), stigmast-4-en-3-one (4.65%), and campesterol (4.16%).

2.3 Cotton

Cotton is a staple fiber, which means it is made up of multiple, differing-length fibers. Cotton fabric is produced from the natural fibers of cotton plants belonging to the genus Gossypium. Cotton is made up mostly of cellulose, an insoluble organic component essential to plant structure, and is a soft and fluffy fiber. Cotton has naturally hollow fibers that are cool, absorbent, supple, and breathable. Cotton fibers can store water 24-27 times their weight. They are robust, dye-absorbing, and resistant to abrasion and high temperatures.

2.3.1 History of Cotton Fibre

Cotton comes from the Arabic word "quton." India was the first country to grow cotton in the fifth millennium B.C.. The first cotton gin, a tool used to separate cotton fluff from plant seeds, was invented in India in the 13th century. The cotton gin simplified and accelerated cotton production, allowing the fiber to proliferate as a popular textile.

During the Industrial Revolution, Britain became a major cotton producer thanks to the creation of new technologies such as the spinning jenny, spinning frame, and spinning mule. All of these spinning machines enabled producers to spin cotton at a higher pace.
However, it was American Eli Whitney's creation of the mechanical cotton gin that resulted in increased cotton production in the United States and Europe. This revolutionary tool, which separated the seeds from the cotton swiftly and efficiently using machine power, reduced the

hours of manual effort required to create a bale of cotton from 600 to only 12. Around the same time, America, particularly the Southern states, began producing higher-quality cotton, with fibers that were slightly longer and stronger.

Despite occasional production declines, such as during the Civil War, the United States remains one of the world's largest cotton producers, trailing only China and India.

2.3.2 Production of Cotton Fibre

Nearly every tropical and subtropical region on Earth, including the US, China, India, Pakistan, Uzbekistan, Brazil, and Turkey, is home to cotton plantations. Texas is the greatest cotton producer in the United States, with the South Plains region in the northern part of the state being the world's largest contiguous cotton-growing area.

Cotton production is a complex process that begins with cotton seed sowing, continues with cotton crop harvesting, and concludes with cotton ginning. While cotton was originally picked and sorted by hand, most cotton production now begins with a cotton picker or cotton stripper, which removes the boll from the plant. After cotton is picked, it is baled and stored in the fields before being transported to the gins. At the gins, cotton bales are cleaned and fluffed to remove dirt, seeds, and lint. After the cotton has been through the gins and thoroughly separated from the seeds, it is compressed and stored before being shipped to textile mills for further manufacture.

2.3.3 Chemical Composition & Structure of Cotton

A chemical composition provides the identity, order, and ratio of chemical constituents that form a compound through chemical and atomic bonding. Chemical formulas can be used to express the relative proportions of constituents in a compound.

Table 2.1: Chemical Composition of Cotton Fiber

Component	Amount (dry basis)%	Main location	Primary wall (%)
Cellulose	94	Secondary wall	48
Protein	1.9	Lumen	12
Pectin substance	0.9	Primary wall	12
Oil, fat & wax	0.6	Cuticle	7
Ash	1.2		3
Other organic acids, such as citric and malic	0.8	Lumen	14
Total sugar	0.3	Primary wall	
Pigment	Trace		
Others	0.9		

Pure cellulose, a polymer that occurs naturally, makes up cotton.Cellulose, a carbohydrate, is made up of a chain of glucose (sugar) molecules.

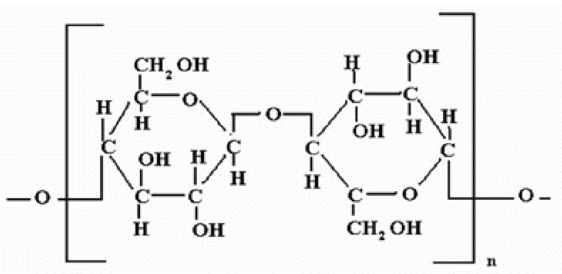


Fig 2.1: Chemical Structure of Cotton

2.3.4 Pretreatment of Cotton

Grey fabric inspection:

This is used to detect fabric problems in the gray state. Visual examination is performed using either a lengthy inspection table or a specialized machine. Fabric salvages are typically marked with colorful threads or other markings to indicate defects. If the number of flaws exceeds the inspection requirement and cannot be remedied, products will be rejected at this stage. After examination, little sections are sewed together to form a continuous shape.

Scouring:

Scouring removes contaminants and dirt from gray textiles, resulting in improved white ground and water-absorbing characteristics for color processing. Cotton commonly contains impurities such as seed pieces, wax, oil, dirt, and natural colors. To score, strong alkalis (e.g., caustic soda) are typically treated with detergent at a near-boiling temperature for an appropriate duration. Excessive scouring causes cellulose oxidation, reducing fabric strength.

Bleaching:

Bleaching brightens the whiteness of scoured fabrics, making them suitable for fluorescent whitening and vibrant colors. Common bleaching chemicals include sodium hypochlorite ($NaClO$), sodium chlorite ($NaClO_2$), and hydrogen peroxide (H_2O_2).

Bio-polishing:

Bio-polishing removes protruding fibers using enzymes, resulting in a smoother and softer feel. This improves the fabric's look and comfort. Enzymes are employed in cotton bio-polishing to selectively remove loose fibers from the fabric or yarn surface. The Bio-Polishing method can enhance the quality of cotton and other cellulosic yarns and textiles. Cellulase enzyme is employed in cotton bio-polishing to break down microfibrils (hairs or fuzz) on the yarn's surface, which are vulnerable to enzymatic attack.

2.4 Mordants

The long-established mordanting method, which is linked to textile dying, improved the fastness and dye absorption of the dye, mostly for cotton samples (M. Zarkogianni, Eleni Mikropoulou, E. Varella, E. Tsatsaroni - 2011: Colour and fastness of natural dyes: revival of traditional dyeing techniques) .A mordant, often known as a dye fixative, is a chemical used to permanently adhere dyes to textiles. It forms a coordination complex with the dye, which binds to the fiber. As a result, mordants improve the colored yarn or fabric's wash and lightfastness properties. Mordants are required to set the color when utilizing natural colors. diverse mordants will produce diverse colors from the same color. A mordant is a chemical substance that initiates a reaction between dye and fabric. Mordants are commonly used for dyeing and color printing in textiles, particularly for plant-based cotton fibers. The mordant affects the dye source, but does not serve as a color source in its own right. During dyeing, the mordant reacts with the fabric, forming a chemical bond that bonds it securely. Metal mordants are polyvalent metal ions that create color-specific coordination complexes.

Types of Mordants

- Metal Salt Mordants
- Plant-based Mordants

2.4 Methods of Mordanting

Mordanting is an important stage in the dyeing process for cotton fabric to ensure that the color remains vivid and lasts longer.

There are numerous ways to mordant cotton cloth, including pre-mordanting, simultaneous mordanting, and post-mordanting.

- Pre-mordanting includes preparing the fabric with a mordant before dyeing, whereas simultaneous mordanting combines the mordant and dye.
- Post-mordanting occurs after the fabric has been colored.
- Simultaneous mordanting: applying and combining dye and mordant at the same time.

Each approach has advantages and can provide various color outputs. It is critical to select the appropriate mordanting procedure based on the desired color intensity and wash fastness of the cloth. Understanding these procedures allows one to create beautifully dyed cotton fabric with long-lasting hues. Mordants that were often used over time were divided into two categories. Acid and basic mordants are used to bind acidic and basic dyes. Tannins, collected from oak nuts or bark, are the primary source of acid in marinades. Vegetable oil is occasionally used. Basic mordants are salts of metals such as aluminum, chromium, iron, copper, zinc, or tin. Most vegetable colors require a mordant to be permanently set in fiber. Tannic acid apparently blocks those sites that normally would be contrasted by uranyl acetate or some other staining compounds (B. Afzelius -1992 : Section staining for electron microscopy using tannic acid as a mordant: A simple method for visualization of glycogen and collagen).

CHAPTER-3

MATERIALS & METHODS

3.1 Materials:

Fabric:

100% single jersey cotton knit fabric, GSM 160 was collected from Interstoff Apparels Ltd. Chandora, Kaliakoir; Gazipur, Bangladesh. This cotton knit fabric is a pre-treatment fabric.

Dragon Fruit:

2 pieces of Dragon fruit were collected from the local market of Boro Mogbazar, Dhaka. The total weight of 2 pieces of dragon fruit was 450gm.

3.2 Chemicals:

Mordants:

Alum (potassium aluminum sulfate), Iron (ferrous sulfate), Vinegar and Tannic acid were used as mordants. Alum (potassium aluminum sulfate) and iron (ferrous sulfate were collected from the wet processing lab of Daffodil International University. Vinegar was collected from the regular grocery store of ECB Chottor, Zia Colony Road, Dhaka-1206. To get the Tannic acid we used Tea leaves which were collected from the Tea garden of Sylhet.

Wetting Agent:

We have used BENTECH CHEMICAL CO., Ltd Wetting agent. **BENWET EH-K** improves and maintains the wet-ability in reactive and sulfur dyeing at high temperatures by its uniform composition and reduces the dull look of sulphur dyeing to improve bright shades.

Levelling Agent:

Here, we use BENTECH CHEMICAL CO., Ltd Levelling agent. **BENLEVER RL-T** is a good leveling effect on direct and reactive dyestuffs, offering the same depth of shade and uniformity of color on fabrics, and the same performance as conventional dyeing.

Sequestering Agent: Sequestering agent BENQUEST C-80F from BENTECH CHEMICAL CO.,Ltd which removes calcium, magnesium and iron from the cotton. BENQUEST C-80F can be used at each step of the pretreatment of cotton, de-sizing, scouring, and bleaching.

Acetic Acid:

To maintain PH level 4.5-5

Caustic Soda : Caustic soda is added into the solution to maintain the pH levels during reduction cleaning.

3.3 Tools and Machines

Dyeing machine:

Figure 3.1: Eco Dyer

Specification of this machine:

Brand Name	Rapid
Model Name	Eco-24S
Origin	China
Temperature Range	20 - 140°C
Heating source	Electric heat-conducting
Temperature Control	RAPID Touch Screen Type Controller (50 Programs x 50 steps)
Power consumption	4.5 KW
Applied For	Lab Sample dying

Drying Oven:

Figure 3.2: Drying Oven

Specification of this machine:

Brand Name	TAISTE LAB SCIENCE INC
Model Name	WHL-25A
Origin	USA
Temperature Range	RT+10～300℃
Capacity	25 Liter
Shelf	2pcs
Timer	0～9999minutes (with timed wait)
Application	Mini natural convection drying oven

3.4 Working Procedure:

3.4.1 Dye Preparation from Dragon Fruit:

First, some Dragon fruit was selected. After washing and cutting, take the interior red portion and separate the seeds. Next, the inside piece was blended to extract the red liquid. The juice was collected and then filtered repeatedly. We have blended 200gm of the interior red portion with 1000ml of water. The filtered juice was stored at -4°cool temperature to prevent rot and ensure proper color processing.

Figure : Dragon fruit juice.

3.5 Sequence of Dyeing

Weighting of cotton knit fabric to be dyed

↓

Calculation

↓

Mordanting

↓

Dyeing

↓

Post dye wash

3.6 Mordanting:

The clean scouring cotton cloths were treated with four different Mordent Alum (potassium aluminum sulfate) , Iron (ferrous sulfate), Vinegar and Tannic Acid.

3.7 Dyeing:

3.7.1 Dyeing in Acidic Condition:

The extracted dye solution was used to dye the mordanted cotton fabric for 30 minutes in the dyeing apparatus while maintaining a material-to-dye solution ratio of 1:30 at a pH of 4-4.5 and a temperature of 80°C. The colored samples were removed and squeezed, after which the cloth was hot-washed with water and cold water. The fabric was finally dried using a dry machine.

3.7.2 Dyeing in Neutral Condition:

The extracted dye solution was used to dye the mordanted cotton fabric for 30 minutes in the dyeing apparatus while maintaining a material-to-dye solution ratio of 1:30 at a pH of 6.5-7 and a temperature of 80°C. The colored samples were removed and squeezed, after which the cloth was hot-washed with water and cold water. The fabric was finally dried using a dry machine.

3.7.3 Dyeing in Alkaline Condition:

The extracted dye solution was used to dye the mordanted cotton fabric for 30 minutes in the dyeing apparatus while maintaining a material-to-dye solution ratio of 1:30 at a pH of 10-10.5 and a temperature of 80°C. The colored samples were removed and squeezed, after which the cloth was hot-washed with water and cold water. The fabric was finally dried using a dry machine.

3.8 Experimental Data and Analysis

Treatment of Cotton Fabric with Dyes Extract from Dragon fruit In pH different condition:

Table 01 : Cotton fabric mordant with alum and dyed in 10 pH condition :

Recipe For Mordanting	
Sample Weight	10gm
Alum	1g/l, S.S=1% (20ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	160ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Caustic soda	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	10
M:L	1:20

Table 02: Cotton fabric mordant with alum and dyed in 6.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Alum	1g/l, S.S=1% (20ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	160ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	110ml
Temperature	80°C
Time	30min
pH	6.5
M:L	1:20

Table 03: Cotton fabric mordant with alum and dyed in 4.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Alum	1g/l, S.S=1% (20ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	160ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Acetic Acid	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	4.5
M:L	1:20

Table 04: Cotton fabric mordanted with Ferrous Sulfate and dyed in 10 pH condition :

Recipe For Mordanting	
Sample Weight	10gm
Ferrous Sulfate	1g/l, S.S=1% (20ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	160ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)

Caustic soda	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	10
M:L	1:20

Table 05: Cotton fabric mordant with alum and dyed in 6.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Ferrous Sulfate	1g/l, S.S=1% (20ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	160ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	110ml
Temperature	80°C
Time	30min
pH	6.5
M:L	1:20

Table 06: Cotton fabric mordant with alum and dyed in 4.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Ferrous Sulfate	1g/l, S.S=1% (20ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	160ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Acetic Acid	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	4.5
M:L	1:20

Table 07: Cotton fabric mordanted with Ferrous Sulfate and dyed in 10 pH condition :

Recipe For Mordanting	
Sample Weight	10gm
Tannic Acid	10g/l, S.S=5% (40ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	140ml

Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Caustic soda	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	10
M:L	1:20

Table 08: Cotton fabric mordant with alum and dyed in 6.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Tannic Acid	10g/l, S.S=5% (40ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	140ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)

Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	110ml
Temperature	80°C
Time	30min
pH	6.5
M:L	1:20

Sample :

Table 09: Cotton fabric mordant with alum and dyed in 4.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Tannic Acid	10g/l, S.S=5% (40ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	140ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Acetic Acid	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	4.5
M:L	1:20

Table 10: Cotton fabric mordanted with Ferrous Sulfate and dyed in 10 pH condition :

Recipe For Mordanting	
Sample Weight	10gm
Vinegar	10g/l, S.S=5% (40ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	140ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Caustic soda	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	10
M:L	1:20

Table 11: Cotton fabric mordant with alum and dyed in 6.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Vinegar	10g/l, S.S=5% (40ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	140ml
Time	20min
Temperature	100°C

M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	110ml
Temperature	80°C
Time	30min
pH	6.5
M:L	1:20

Sample :

Table 12: Cotton fabric mordant with alum and dyed in 4.5 pH condition:

Recipe For Mordanting	
Sample Weight	10gm
Vinegar	10g/l, S.S=5% (40ml)
Sequestering Agent	1g/l, S.S=1% (20ml)
Water	140ml
Time	20min
Temperature	100°C
M:L	1:20

Recipe For Dyeing	
Sample Weight	10gm
Wetting agent	1g/l, S.S=1% (20ml)
Dye amount	50ml

Sequestering Agent	1g/l, S.S=1% (20ml)
Acetic Acid	1g/l, S.S=1% (20ml)
Water	90ml
Temperature	80°C
Time	30min
pH	4.5
M:L	1:20

3.9 Material for Test Evaluation:

Multi Fibre Fabric:

Multi Fibre Fabric was collected from the physical Lab of Ben Tech Chemical Co., Ltd. It was used during the wash fastness test.

Crocking cloth:

Crocking fabric made of 100% cotton, desized, bleached without optical brightener, with a 1/1 plain construction and EPI 32 and PPI 33, was retrieved from the Physical Lab of Ha-meem Group, Tongi Zone. It was used in the rubbing fastness test.

3.9.1 Machines for Test Evaluation:

Rubbing Machine:

Figure: Motor Crock Meter

Specification of this machine:

Brand Name	James Heal
Model Name	WHL-25A
Origin	UK
Approximate net weight	17.3Kg
Space requirements	Height 23cm Width 66cm Depth 32cm

Colorfastness to Wash Testing Machine

Specification of this machine:

Brand Name	SDL-Atlas
Model Name	M228AA Launder-Ometer
Origin	UK
Capacity	550 ml and 1200 ml containers
Sample	Test up to 20 samples

Grey scale for Assessing Colour Change:

Grey scale for assessing Colour Change (ISO 105-A02) was collected from physical Lab of of Ha-meem Group, Tongi Zone.

Grey scale for Assessing Staining:

Grey scale for assessing Staining (ISO 105-A03) was collected from physical Lab of Ha-meem Group, Tongi Zone.

Spectrophotometer:

Figure : Spectrophotometer

Brand Name	XRITE
Model Name	Ci7600
Origin	UK

Formulation Software : Color iMatch

Other Tools and Machines :

- Electronic Balance
- Electric Heater
- Thermometer
- Pipette
- pH meter
- Beaker
- Measuring Cylinder
- Blender

3.10 Colour Fastness Methods:

3.10.1 Wash Fastness

Wash fastness was tested using the ISO 105 C02 method, which involved stitching a 10 cm by 4 cm colored cotton fabric to a 10 cm by 4 cm DW multi-fiber fabric. The composite fabric was washed for 45 minutes at 50°C in a solution of ordinary soap (5 g/l) with a material-to-liquor ratio of 1:50. The dyed cotton fabric was examined for color change using the ISO 105-A02 greyscale, while the DW multi-fiber fabric was assessed for staining using the ISO 105-A03 standard.

3.10.2 Rubbing Fastness

Rubbing fastness was tested using the ISO 105-X12 method, To evaluate rubbing fastness, a 5 cm by 14 cm piece of colored cotton fabric was placed in the Crock meter and rubbed ten times in ten seconds using a 5 cm by 5 cm dry crocking cloth and a 5 cm by 5 cm wet crocking cloth, respectively. The crocking fabric was assessed for staining on a grey scale (ISO 105-A03).

3. 11 Evaluation of Colour Fastness:

3.11.1 Evaluation of Change in Colour

The tested specimen and the original sample were placed next to each other in the same direction and location, along with the relevant grayscale. Using the grey scale (ISO 105-A02) to measure color shift and viewing perpendicular to the surface, Under 45° of light, the original and tested specimens' visual differences were examined, and a suitable color fastness rating was given.

Ratings of color change:

Grade 1- Very poor (great loss in depth)

Grade 2- Poor (significant loss)

Grade 3- Fair (Appreciable loss)

Grade 4- Good (Slight loss in depth)

Grade 5- Excellent (No change)

3.11.2 Evaluation for Staining

Clean samples and stained multi-fiber fabrics were put next to one other, with suitable gray scale between them, in the same plane and orientation. The visual difference between the unstained and stained sample in the presence of light at a 45° angle was compared by observing perpendicular to the plane of the surface while using the grey scale for measuring staining (ISO 105-A03). An appropriate color fastness grade was then supplied.

Ratings for staining:
Grade 1- Very poor (Deep staining)
Grade 2- Poor (Significant staining)
Grade 3- Fair (Moderate staining)
Grade 4- Good (Very slight staining)
Grade 5- Excellent (No staining)

CHAPTER-4

RESULTS AND DISCUSSIONS

4.1 Evaluation of dyed samples in different pH :

Mordant	pH	Sample
	10	
Alum	6.5	
	4.5	
	10	
Ferrous Sulfate	6.5	

	4.5	
Tannic Acid	**10**	
	6.5	
	4.5	
Vinegar	**10**	
	6.5	

	4.5	

4.1.1 Evaluation of Dyed Sample :

Without vinegar, every mordant has its color so the tone of dyed the samples is different to each other due to the color of the mordant. We can also see the dyeing solution pH goes high the dyed sample produces a lighter shade and when the pH goes down the shade is darker than the high pH.

4.2 Evaluation of fastness properties of dyed samples:

4.2.1 Colorfastness to Wash:

Table 4.1 Color fastness to Wash (Alum) :

Mordant	pH	Colour Change	Staining					
			Di-Acetate	Bleached Cotton	Acrylic	Polyamide	Polyester	Wool
Alum	10	4/5	4/5	4/5	4/5	5	5	4/5
	6.5	4/5	4/5	4	4/5	5	5	4
	4	4/5	4/5	4	4/5	5	5	4

Table 4.2 Color fastness to Wash (FeSO4) ;

Mordant	pH	Colour Change	Staining					
			Di-Acetate	Bleached Cotton	Acrylic	Polyamide	Polyester	Wool
	10	4/5	4/5	4/5	4/5	5	5	4/5

Ferrous Sulfate	6.5	4/5	4/5	4	4/5	5	5	4
	4	4/5	4/5	4	4/5	5	5	4

Table 4.3 Color fastness to Wash (Tannic Acid) :

Mordant	pH	Colour Change	Staining					
			Di-Acetate	Bleached Cotton	Acrylic	Polyamide	Polyester	Wool
Tannic Acid	10	4	4	4	4/5	4/5	4/5	3/4
	6.5	4	4	3/4	4	4/5	4/5	3/4
	4	4	4	3/4	4	4/5	4/5	3/4

Table 4.4 Color fastness to Wash (Vinegar) :

Mordant	pH	Colour Change	Staining					
			Di-Acetate	Bleached Cotton	Acrylic	Polyamide	Polyester	Wool
Vinegar	10	5	5	5	5	5	5	5
	6.5	4/5	4	4	5	5	5	4
	4	4/5	4	4	5	5	5	4

4.2.1 Evaluation of color fastness to Wash:

Greyscale grading has been applied to color shift and staining. When tested on DW multi-fiber fabric, the colored fabric had a staining scale rating of 4-5 for the highest cases of color fastness to washing, indicating good resistance to color straining. For the dyed fabric the color change rating is 4-5 according to the grey scale for color change.

4.2.2 Color fastness to rubbing

Table 4.5 Color fastness to rubbing (Alum)

pH	Mordant	Dry	Wet
10	Alum	4/5	3/4
6.5		4/5	3/4
4		4	3

Table 4.6 Color fastness to rubbing (Ferrous Sulfate)

pH	Mordant	Dry	Wet
10	Ferrous Sulfate	4	4
6.5		4	3/4
4		4/5	3/4

Table 4.7 Color fastness to rubbing (Tannic Acid)

pH	Mordant	Dry	Wet
10	Tannic Acid	4/5	4
6.5		4	3
4		3/4	3

Table 4.8 Color fastness to rubbing (Vinegar)

pH	Mordant	Dry	Wet
10	Vinegar	4	3/4
6.5		4/5	4
4		5	4

4.2.3 Evaluation of color fastness to Rubbing:

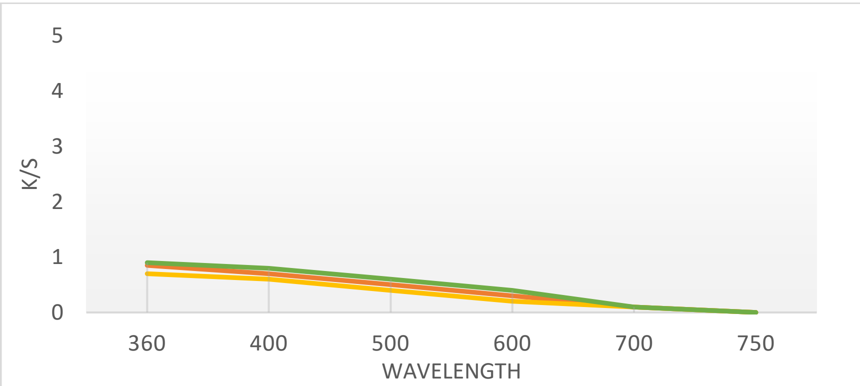
The grading of the color fastness to rubbing for dry process rating was between 4-5 sometimes 5 but maximum time 4 and the wet process rating was also between 3-4 but maximum time the rating was 3.

4.3 Evaluation of Spectrophotometer Result:

For Alum as a mordant - We have taken the sample dyed in Acidic as a standard.

Standard Sample result:

Condition	L*	a*	b*	C*	h°
D65-10	77.49	6.41	11.45	13.12	60.76
TL84-10	78.25	6.51	13.13	14.65	63.61
A-10	78.99	9.00	13.40	16.14	56.12



Orange for Standard
Green for Neutral
Yellow for Alkaline

K/S vs Wavelength

Neutral condition dyed sample result against standard:

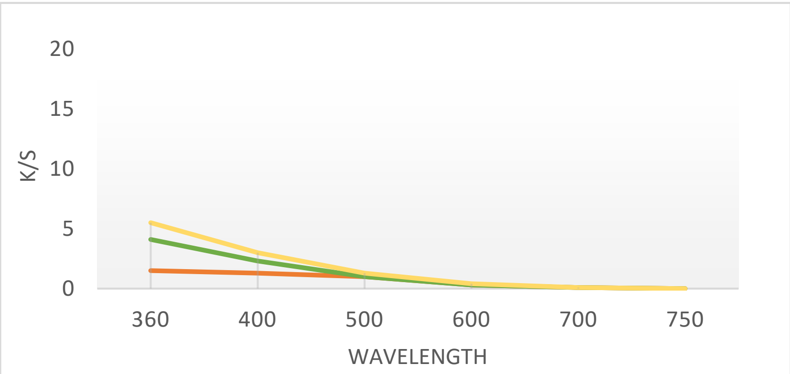
Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	1.91 L	-2.73 G	-4.22 B	-5.01 D	0.41 Y	3.84	FAILED	0.82
TL84-10	1.58 L	2.53 G	-4.93 B	-5.54 D	-0.08 Y	3.94		
A-10	1.34 L	3.33 G	-5.08 B	-6.07 D	-0.08 R	4.11		

Alkaline condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	-2.17 D	-3.49 G	-1.59 B	-2.84 D	2.58 Y	5.08	FAILED	0.51
TL84-10	-2.42 D	-3.30 G	-1.99 B	-3.07 D	2.34 Y	4.47		
A-10	-2.67 D	-3.49 G	-2.55 B	-3.97 D	1.70 Y	4.16		

For Ferrous as a mordant - We have taken the sample dyed in Acidic as a standard.

Standard Sample result:



Orange for Standard
Green for Neutral
Yellow for Alkaline

K/S vs Wavelength

Neutral condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	0.03 L	-1.36 G	7.95 Y	6.20 B	5.15 Y	8.65	FAILED	0.86
TL84-10	0.31 L	-1.06 G	8.70 Y	7.24 B	4.95 Y	8.09		
A-10	0.27 L	0.06 R	7.60 Y	6.47 B	3.99 Y	6.52		

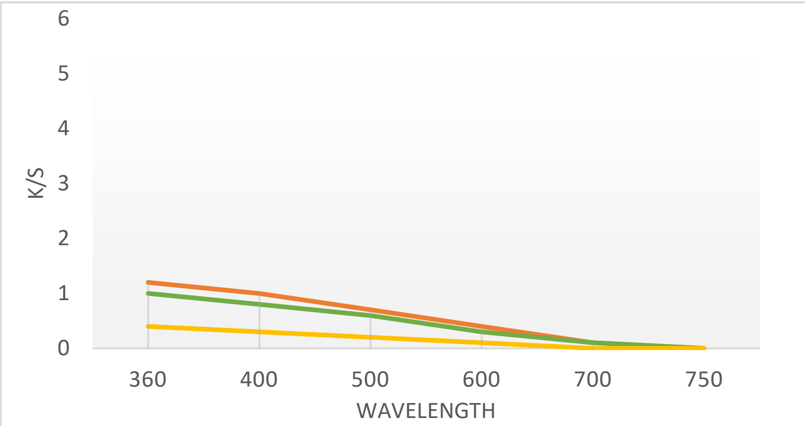
Alkaline condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	-7.26 D	1.15 R	13.42 Y	12.23 B	5.65 Y	11.43	FAILED	1.99
TL84-10	-6.55 D	0.54 R	15.18 Y	13.84 B	6.25 Y	11.91		
A-10	-6.51 D	2.69 R	13.83 Y	13.20 B	4.92 Y	9.99		

For Vinegar as a mordant - We have taken the sample dyed in Acidic as a standard.

Standard Sample result:

Condition	L*	a*	b*	C*	h°
D65-10	72.93	4.47	10.39	11.31	66.74
TL84-10	73.52	4.60	11.74	12.61	68.62
A-10	74.14	6.95	11.80	13.70	59.49



Orange for Standard
Green for Neutral
Yellow for Alkaline

K/S vs Wavelength

Neutral condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	4.11 L	0.87 R	-1.56 B	-1.00 D	-1.49 R	3.05	FAILED	0.15
TL84-10	4.09 L	0.90 R	-1.71 B	-1.17 D	-1.54 R	3.03		
A-10	3.45 L	0.40 R	-1.39 B	-0.95 D	-1.09 R	2.58		

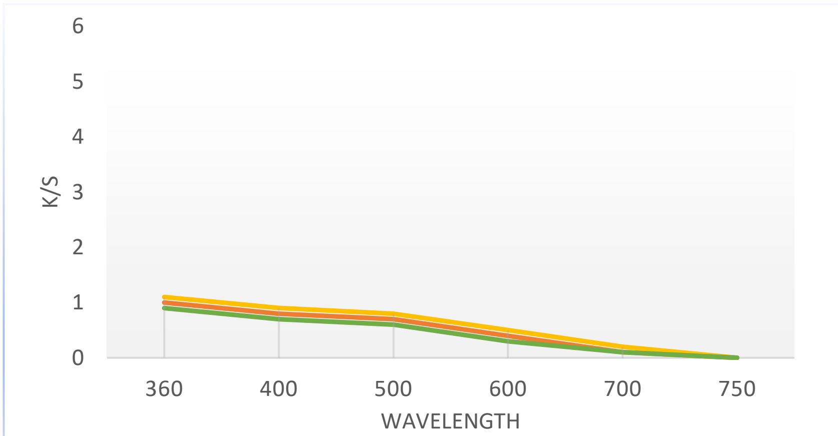
Alkaline condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	17.61 L	-0.73 G	-5.51 B	-5.16 B	-2.06 R	8.60	FAILED	0.69
TL84-10	17.40 L	-0.75 G	-6.17 B	-5.84 B	-2.13 R	8.65		
A-10	17.17 L	-2.25 G	-5.83 B	-6.10 B	-1.38 R	8.26		

For Tannic acid as a mordant - We have taken the sample dyed in Acidic as a standard.

Standard Sample result:

Condition	L*	a*	b*	C*	h°
D65-10	75.40	6.76	8.75	11.06	52.29
TL84-10	76.04	6.77	10	12.08	55.89
A-10	76.77	8.60	10.74	13.75	51.32



Orange for Standard
Green for Neutral
Yellow for Alkaline

K/S vs Wavelength

Neutral condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	3.60 L	-1.15 G	-0.33 B	-0.94 D	0.74 Y	2.11	FAILED	0.03
TL84-10	3.57 L	-1.14 G	-0.32 B	-0.88 D	0.80 Y	2.16		
A-10	3.45 L	-1.13 G	-0.64 B	-1.19 D	0.51 Y	1.80		

Alkaline condition dyed sample result against standard:

Condition	DL*	Da*	Db*	DC*	Dh°	DEcmc	P/F DEcmc	MI-(1,2)
D65-10	2.15 L	1.34 R	-0.79 B	0.30 B	-1.53 R	3.05	FAILED	0.07
TL84-10	2.17 L	1.28 R	-0.82 B	0.14 B	-1.53 R	3.08		
A-10	2.26 L	1.08 R	-0.49 B	0.34 B	-1.14 R	2.23		

CHAPTER-5

CONCLUSION

5.1 Conclusion:

Accordingly, the findings of this study indicate that dragon fruit has the potential to be used as a source of dye for cotton. However, fruit dyes can be employed commercially but to get the perfect shade is quite impossible every time with the same recipe.

In this investigation, we have found that the dye extraction was different with different pH and mordant at the same temperature.

While testing the fastness (wash & rubbing) properties of dyed fabric, surface color was affected by washing, and rest fastness properties were good. To get good fastness qualities, the bond between the dye and the fabric is sufficient. The dye extraction was good in acidic conditions and the most effective mordant between the four are Alum and Tannic Acid.

This study was interrupted due to many limitations of ours. The result may vary in different aspects. Instated cotton different fabrics may show differences in different pH. For further study on this topic, we are suggesting using different type of fabric like silk, jute and others with different pH conditions with other mordant to find a proper way to use dragon fruit as a commercially useable dye.

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