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# Evaluation of colourfastness properties of cotton fabric dyed with pomegranate rind extract dye

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**Abstract**
In today's world, every industry is moving towards a more environmentally friendly surroundings. The use of natural dyes continues to rise as people become more conscious of ecology, the environment, and pollution control. This paper describes how cotton fabric is dyed using natural dyes extracted from pomegranate peel. The mordants used were alum, myrobalan and banana pseudo stem. The colourfastness properties and colour co-ordinates of dyed fabrics were evaluated and the fabric samples showed very fair to good ratings of colourfastness with slightly stained to no staining.

**Keywords:** Cotton, natural dye, pomegranate rind, mordant, colourfastness, co-ordinates

## 1. Introduction
Colours are fascinating and add beauty to our world. Man's quest for beauty led to the discovery of colouring matter from natural sources such as plants and animals. Till the invention of mauve by William H. Perkins in 1856, the primary source of colour known to man was natural colourants (Farid, 2015) [4]. The rainbow of colours that nature has given us draw attention from all over the world to a colourful natural world. Because of the numerous shades of colour in the textile materials, the textile industry serves as an important aspect of this colourful worlds. These shades of colour expresses emotions, enhance the visual and aesthetic appearance. Dyeing refers to the technique of imparting colour to fabrics (Zubairu *et al.*, 2015; Purwar, 2016; Kodzoman, 2019) [20, 14, 10]. The peels of the pomegranate fruit constitute about 60% of its weight (Karthikeyan and Vidya, 2019) [8]. The peels can be utilised as a natural dye in textile dyeing process. The chemical component granatonine gives its colour which contains the alkaloid N-methyl Granatonine (Laleitha *et al.*, 2020) [13]. The use of non-allergic, non-toxic, and ecologically friendly natural dyes on textiles has become increasingly important as a result of growing environmental awareness and the need to avoid some hazardous synthetic colours (Tamilarasi and Banuchitra, 2021) [17].
To increase natural dyes' affinity for textiles and create distinct dye shades with varying degrees of colour fastness, the dyeing industry uses mordants. When metallic or mineral salts are added to a natural dye bath, the dye is either intensified or the hue is altered. They also have a significant impact on how well the final shade is light- and wash-fast (Laleitha *et al.*, 2020) [13]. There are many levels of colourfastness to light and many different factors, such as fibre types, dyes, colour combinations, the atmospheric condition, sample moisture content ratios, temperature, and others, can affect colourfastness to light (Kumpikaite *et al.*, 2021) [12]. The process through which we define, produce, and visualise colour is known as a colour space. Humans identify colour according to its brightness, hue, and colourfulness. Three co-ordinates, or parameters, are typically used to specify a colour as well as describe its position within the specified colour space (Waskale and Bhong, 2017) [19].
Cotton is a natural and eco-friendly fibre. The "King of Fibre," cotton, is one of the cheapest natural fibres with definite inherent advantages. The natural dyed cotton represents a good opportunity for making clothing and value-added utility. Cotton occupies a dominant position among textile fibres because it accounts for more than 80% of all fibre consumption in India. The appealing characteristic of cotton is that it draws attention to both young and old, contemporary and traditional men and women. Cotton is used as an essential textile material because of its affordability and abundance as well as several other qualities including absorbency, strength, and durability (Rajeswari, 2020) [15].

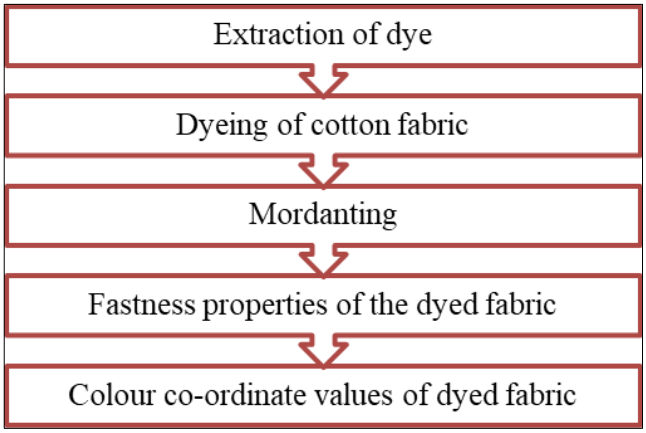
With this back ground information, it is thought to apply extract of pomegranate rind on cotton fabrics with different mordants to obtain a better result. The objective of the present research work was to analysis the colourfastness properties of dyed fabrics.

## 2. Materials and Methods

### 2.1 Materials

Pomegranate rind was selected for the extraction of dye and collected from the fruit juice shop present in the local market of Jorhat district of Assam. Mordants such as alum, myrobalan and banana pseudo stem were selected for the study. The cotton fabric was collected from the local market of Jorhat district of Assam.

### 2.2 Methods




**Flowchart 1:** Methodology

#### 2.2.1 Preparation of pomegranate rind, myrobalan and banana pseudo stem

Pomegranate rind was cleanedto remove the impurities and it was sundried and was ground into powdered form for further use (Kulkarni *et al.*, 2011) [11] (Fig. 1).The natural mordant myrobalan were cleaned with fresh water and cut into small pieces and dried under sunlight. Then it was ground into powdered form and kept in a tight container (Tamuli, 2022) [18] (Fig. 2).Banana sap was collected from the pseudo stem of *Musa chinensis* and it was being pressed. To filter the extracted mordant, a sieve was used (Gogoi, 2022) [5] (Fig. 3).

**Fig 1:** Pomegranate powder

**Fig 2:** Myrobalan powder


**Fig 3:** Banana sap

#### 2.2.2 Pre-treatment of cotton fabric

##### 2.2.2.1 Scouring

The chemicals such as sodium carbonate (2.0%) and sodium hydroxide (5.0%) were takenin a dye bath along with water. Cotton fabric was then added into the bath and the temperature was raised slowly to 80-90 °C maintaining M:L=1:30. The process was continued for 60 minutes with occasional stirring. The fabric samples were washed properly with cold water and dried at suitable temperature (Handique, 2022) [6].

##### 2.2.2.2 Bleaching

The pre wetted cotton fabric was dipped into bleaching bath along with 1%Hydrogen peroxide ($H_2O_2$) at a temperature of 50 °C and occasional stirring was done for 30 minutes maintaining M:L=1:50. The bleached cotton fabric was rinsed with water and then dried at ambient temperature (Handique, 2022) [6].

#### 2.2.3 Extraction of Dye

An alkaline medium was used for extraction of dye from pomegranate rind by taking 3 grams of dye material in 100 ml of distilled water at 100 °C for 75 min. The extracted dye liquor was filtered with fine filter paper 3 times to get clear dye liquor. Dye absorption by the fibre was determine from the percentage of dye absorption by subjecting the dye solution before and after dyeing through visual light of a specific wavelength using a spectrophotometer.

### 2.2.4 Dyeing of cotton fabric

Bleached cotton fabric were weighed for dyeing at 70 °C for 60 min by taking a material-to-liquor ratio of 1:30. The optical density obtained from the dye liquor before and after dyeing was recorded. The dye absorption (%) of the yarn determined by using the following formulae:

$$\%\ \text{of dye absorption} = \frac{\text{OD of the liquor before dyeing} - \text{OD of the liquor after dyeing}}{\text{OD of the liquor before dyeing}} \times 100$$

### 2.2.5 Mordanting

The simultaneous mordanting method was carried out on cotton fabric using 1% of alum, 1.2% of myrobalanand 6% of banana pseudo stem at 60°C for 45 min. keeping the material-to-liquor ratio of 1:50.

### 2.2.6 Evaluation of colourfastness properties of the dyed fabric

The natural dyed cotton fabric samples were tested for the following fastness types:

#### 2.2.6.1 Colour fastness to sunlight

Colour fastness to sunlight of cotton fabric was done by observing fading action of samples when exposing to sunlight. The fabric samples were cut into 3×8 inches long pieces.The samples were exposed to the sunlight simultaneously from 9 am to 5 pm. After 48 hours of exposure, in the interval of 8, 16, 24, 32, 40 and 48 hours, the samples were evaluated for their colour change with the help of grey scale.

#### 2.2.6.2 Colour fastness to washing

Colourfastness to washing test was carried out to check whether the dye applied on the textile material was affected by washing or not. Wash Fastness test was carried out by using an instrument called Launder-O-Meter(AATCC method).The fabric samples were kept in a metal jar containing 100 ml of 5% soap solution and stainless-steel balls under constant temperature. The metal jar was sealed before it was immersed and required amount of time was used for running the Launder-O-Meter. The samples were vigorously shaken for 1 minute with distilled water at 40 °C. The samples were poured in 100 ml of 0.015% acetic acid solution for 1 minute at room temperature. The samples were then washed again in 100 ml of water for one minute and then the samples were squeezed, dried and ironed.

#### 2.2.6.3 Colour fastness to crocking or rubbing (dry and wet)

Colourfastness to crocking test was carried out to check whether the colour is transferred from the dyed fabric sample to another textile material or not by rubbing treatment. The fabric sample was kept at the base of Crock-O-Meter. A white cloth was taken and mounted on the end of the finger with the help of special wire clip which was projected downward from the weighted sliding arm. For wet crocking the white cloth was completely wet out and reducing the moisture content by evaporating process and mounted on the end of the finger. The covered finger was inserted into the fabric sample and the sample began to be crocked by sliding back and forth 20 times while being rotated at a pace of 10 full rotations per second.

#### 2.2.6.4 Colour fastness to pressing (dry and wet)

Colourfastness to pressing test was carried out to check whether the dyed textile material will change or transfer colour or both when subjected to hot pressing. In both wet and dry conditions, the fabric samples were flat ironed using a hot iron. Using the ASTM standard grey scale, the colour changes and colour stains on the adjacent white cloth were evaluated immediately and after two hours.

**2.2.6.5 Dry test:** The fabric samples were ironed for 10 seconds at a specific temperature while being covered in a dry, white cloth.

**2.2.6.6 Wet test:** To wet the white cloths, distilled water was used and excess water was squeezed out. A hot iron set to a certain temperature was used to press the fabric samples for 10 seconds while they were wrapped in a damp cloth.

#### 2.2.6.7 Interpretation of results of the colour fastness test

The indicators for Colour Change (CC) and Colour Staining (CS) were evaluated for each sample accordingly.

**Table 1:** Ratings for Colour Change and Colour Staining

| Colour Change (CC) Ratings | | Colour Staining (CS) ratings | |
|---|---|---|---|
| **Grade** | **Ratings** | **Grade** | **Ratings** |
| 5 | Good | 5 | Negligible or no staining |
| 4 | Very fair | 4 | Slightly stained |
| 3 | Fair | 3 | Noticeable stained |
| 2 | Poor | 2 | Considerably stained |
| 1 | Very poor | 1 | Heavily stained |

### 2.2.7 Colour co-ordinate values of dyed fabric

The colour co-ordinate value of all the dyed samples were determined by CIE Lab system via the spectrophotometer with an average of five times readings in Brightness, Opacity and Colour Tester. In order to show the colour difference between mordanted and non-mordanted samples, the colour parameters L* (depth of colour), a* (positive value redness and negative greenness), and b* (positive value yellowness and negative value blueness) were recorded. The lower value of L* indicate higher depth of colour.

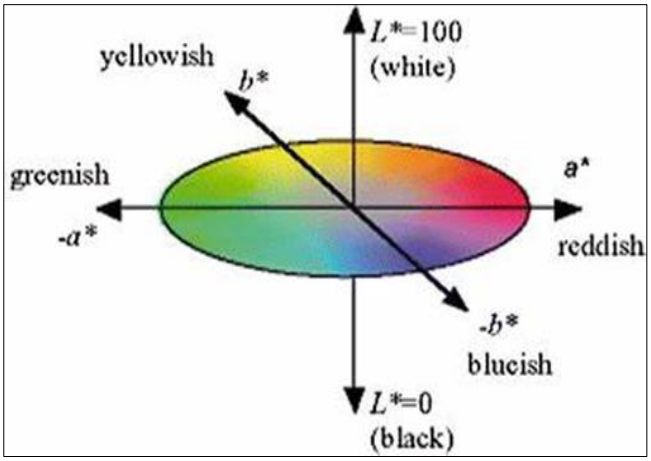



**Fig 4:** Hunter Lab Colour Graph

## 3. Results and Discussion

### 3.1 Evaluation of colour fastness properties of dyed fabric

#### 3.1.1 Colour fastness to sunlight

**Table 2:** Ratings for colour fastness to sunlight

| Sl. No. | Fabric samples | Colourfastness to sunlight |
|---|---|---|
| 1 | Non mordanted | 4 |
| 2 | Myrobalanmordanted | 5 |
| 3 | Alum mordanted | 4 |
| 4 | Banana pseudo stem mordanted | 4 |

Table 2 revealed that myrobalanmordanted fabric showed good colourfastness to sunlight whereas mordant alum, banana pseudo stem and the non mordanted fabric showed very fair colourfastness to sunlight. Good light fastness was observed in fabrics dyed with the dye extracted from pomegranate peel. This may be due to the metal complex formation which protects the chromophore from photolytic degradation (Kulkarni *et al.*, 2011) [11].

#### 3.1.2 Colour fastness to washing

**Table 3:** Ratings for colour fastness to washing

| Sl. No. | Fabric samples | Colourfastness to Washing | |
|---|---|---|---|
| | | CC | CS |
| 1 | Non mordanted | 4 | 5 |
| 2 | Myrobalanmordanted | 5 | 5 |
| 3 | Alum mordanted | 5 | 5 |
| 4 | Banana pseudo stemmordanted | 4 | 5 |

Table 3 revealed that myrobalan and alum mordanted fabric showed good fastness and banana pseudo stem and non mordanted fabric showed very fair fastness to washing. This may be due to the affinity of colouring component through H-bonding and van der Waals forces. The superior washing property of the colorant may also be due to the kinetics and thermodynamic effects of the metal complex formation and alkaline media used in dyeing. In alkaline conditions, tannins are neutralized and good hue can be observed (Adeel *et al.*, 2009) [2]. No colour stained occurred in all the mordanted and non mordanted fabric. This means that it would not affect the colours of the fabrics when the dyed fabric was washed together with other fabrics (Khin and Yee, 2017) [9].

#### 3.1.3 Colour fastness to crocking or rubbing (dry and wet)

**Table 4:** Ratings for colour fastness to crocking or rubbing (dry and wet)

| Sl. No. | Fabric samples | Colourfastness to Crocking | | | |
|---|---|---|---|---|---|
| | | Dry | | Wet | |
| | | CC | CS | CC | CS |
| 1 | Non mordanted | 4 | 5 | 5 | 5 |
| 2 | Myrobalanmordanted | 5 | 4 | 5 | 5 |
| 3 | Alum mordanted | 5 | 4 | 4 | 4 |
| 4 | Banana pseudo stemmordanted | 5 | 5 | 4 | 4 |

From the Table 4it was observed that all the mordanted fabric samples showed good colourfastness to crocking while the fabric sample without mordant showed very fair crocking in dry state. No colour stained occurred in banana pseudo stem mordanted and non mordanted fabric samples in dry state while a slightly stained of colour showed by alum and myrobalanmordanted fabric. In case of wet crocking, myrobalan and non mordanted fabric samples showed good colourfastness and negligible staining, while a very fair colourfastness and a slightly stained of colour occurred in case of alum and banana pseudo stem mordanted fabric. The good rubbing fastness property confirms that almost no superficial loosely held dyes are attached at the fibre surface (Sinnur *et al.*, 2017) [16].

#### 3.1.4 Colour fastness to pressing (dry and wet)

**Table 5:** Ratings for colour fastness to pressing (dry and wet)

| Sl. no. | Fabric samples | Pressing | | | |
|---|---|---|---|---|---|
| | | Dry | | Wet | |
| | | CC | CS | CC | CS |
| 1 | Nonmordanted | 5 | 5 | 5 | 5 |
| 2 | Myrobalanmordanted | 5 | 5 | 5 | 5 |
| 3 | Alum mordanted | 5 | 5 | 5 | 5 |
| 4 | Banana pseudo stemmordanted | 5 | 5 | 5 | 5 |

From the evident of the Table5it was cleared that all the fabric samples showed good colourfastness and negligible colour stained in both dry and wet pressing.

### 3.2 Evaluation of Colour co-ordinate values of dyed fabric

**Table 6:** CIE lab colour co-ordinate values of dyed fabric

| Dyed fabric | CIE Lab values | | |
|---|---|---|---|
| | L* | a* | b* |
| Non mordanted | **80.83** | 2.67 | 15.01 |
| Alum mordanted | 79.65 | 3.53 | 19.36 |
| Myrobalanmordanted | 80.78 | 3.58 | 7.09 |
| Banana pseudo stem mordanted | 79.83 | 3.47 | 15.18 |

Table 6 indicated that the maximum L* value (80.83) was found in the case of non mordanted sample, indicating a lighter shade compared to other samples. The alum mordanted fabric sample showed the lowest L* value (79.65) and as a result, it can be said that alum mordanted fabric exhibited the greater depth of colour. The presence of redness and yellowness in the coloured fabric was indicated by the positive values of a* and b*. Therefore, all of them lie in the yellow-red quadrant of the colour space diagram.

## 4. Conclusion

The pomegranate peel dye has a lot of its potential for usage in many textile production processes because it is recyclable, advantageous for environmental protection, and beneficial for community safety.The fabric dyed with pomegranate rind dye showed very fair to good ratings with slightly stained to negligible staining for colourfastness to sunlight, washing, crocking and pressing.

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