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# Dyeing of banana/cotton union fabric with natural dye and mordants

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## Abstract
Natural dyes could be extracted from plants, minerals or insects. Different plant parts like root, stem, bark, heartwood, flower, leaf, seed and fruit could be used for dye extraction based on dye availability. In the present study, natural dye has been extracted from banana leaves to dye banana/cotton union fabric with natural mordants extracted from onion skin and pomegranate rind. Dyeing was carried out by different mordanting techniques such as pre-mordanting, meta-mordanting, and post-mordanting. The dyed samples were tested and evaluated for colour fastness to laundering, rubbing and perspiration and physical properties such as areal density/GSM, thickness and tensile strength.

**Keywords:** Banana/cotton union fabric, natural dye, natural mordant, onion skin, pomegranate rind

## 1. Introduction
Banana is a widely cultivated horticultural crop in India. The agro-waste generated after banana harvest pose to be a serious issue. Some farmers even burn the dry plant to ashes which contributes to environmental pollution and global warming. To overcome this, the waste plant parts could be used in an efficient way that aids in bio-economy. In the current study, waste banana leaves have been used as a source for the extraction of natural dye. Natural dye from banana leaves is both eco-friendly and inexpensive (Saleh *et al*., 2013) [5]. Also, banana leaf extract shows very good antifungal activity and acetone is the best solvent for extraction followed by ethanol and petroleum ether (Meenashree *et al*., 2014) [3]. Most of the natural dyes are non-substantive in nature and hence require a mordant to fix them to the fibre. Usually, metallic salts such as copper sulphate, ferrous sulphate, alum, chrome, etc. are used as mordants (Uddin, 2014) [6]. Though these chemicals are good mordants they pose problems like skin allergy, especially the chrome and copper mordants. Hence, natural mordants such as tannins are preferable in place of metallic mordants. Pomegranate rind is rich in tannins and has been used in dyeing of silk and wool both in the presence and absence of mordants (Prabhu & Bhute, 2012) [4].

## 2 Materials and Methods
### 2.1 Dye extraction
Banana leaf has been selected as the source for natural dye extraction. The banana variety chosen is Monthan (*Musa paradisiaca*). The leaves were collected from a village in Erode district, Tamil Nadu, India. The collected leaves were washed thoroughly and dried under shade and then ground into powder form. One litre of Acetone (solvent) was taken in the Soxhlet extractor and 140 grams of banana leaf powder was packed and placed in the thimble and the mixture was refluxed at 10° to 50 °C for 32 hours. The extract so obtained was filtered using filter paper and stored in an airtight container.

### 2.2 Mordant preparation
Two natural mordant sources namely onion (*Allium cepa*) skin and pomegranate (*Punica granatum*) fruit rind were selected for the study. The dry skin of onion contains a flavonoid called Quercetin that yields yellow dye (Chen & Chang, 2007) [1] while pomegranate rind yields yellowish brown dye (Das *et al*., 2006) [2]. Since both these dye sources are rich in tannins, they could be used as mordants also. Onion skin (the dry outer skin) was collected from Bharathiar University Hostel and Pomegranate rind from Erode market.

200 grams of onion skin was taken in a bath and 3 litres of water was added and boiled at about 90 °C for 40 minutes. Then it was allowed to cool, filtered and stored in airtight container. The pomegranate rind was dried under shade and broken into small pieces. 200 grams of pomegranate rind was taken in a bath and 3 litres of water was added and boiled at about 90°C for 40 minutes. Then it was allowed to cool, filtered and stored in airtight container.

### 2.3 Mordanting and dyeing of fabric

Banana/cotton (warp-100% cotton yarn, weft- 65% cotton and 35% banana yarn) union fabric, plain weave, was bought from a weaver at Erode and pre-treatments such as desizing, scouring and bleaching were done and the fabric is made suitable for dyeing. Three mordanting techniques namely pre, meta and post mordanting were employed. As higher temperature may degrade the dye and the fabric low temperature, 60°C, is preferred for dyeing. The procedure followed for mordanting and dyeing is shown in Table 1.

**Table 1:** Mordanting and dyeing process

| | **Process** |
|---|---|
| Pre- mordanting | Cotton fabric was treated with mordant for 10 minutes at 60 °C with MLR of 1:5. Then the mordanted fabric was dyed at 60°C for 30 minutes and washed with cold water and dried. |
| Meta- mordanting | Cotton fabric was dyed in a bath containing mordant and dye for 60 minutes at 60 °C with MLR of 1:5. The fabric was washed with cold water and dried. |
| Post- mordanting | Cotton fabric was first dyed with banana leaf dye at 60 °C for 60 minutes and then treated with the mordant for 10 minutes at 60°C. The fabric was washed with cold water and dried. |

## 3. Results and Discussion

The dyed and undyed fabrics were analysed for physical properties such as areal density (GSM: grams per square metre), thickness and tensile strength. Since fastness is the important criteria for coloured textiles, the dyed fabrics were tested for colour fastness to rubbing, washing/laundering and perspiration. The results are tabulated as follows:

**Table 2:** Colour fastness to rubbing (ISO 105 X12: 2001)

| **Fabric** | **Onion skin mordant** | | **Pomegranate rind mordant** | |
|---|---|---|---|---|
| | **Dry** | **Wet** | **Dry** | **Wet** |
| Pre-mordanted | 5 | 4/5 | 5 | 3 |
| Meta-mordanted | 5 | 4 | 4/5 | 2/3 |
| Post-mordanted | 5 | 4 | 5 | 3 |

Table 2 shows the colour fastness to rubbing of the dyed samples. The colour fastness to dry rubbing is best with both the mordants while wet rubbing results are better for onion-skin mordant than pomegranate rind mordant.

**Table 3:** Colour Fastness to Washing (ISO 105 C06: 2010)

| **Fabric** | **Colour Change (grade)** | |
|---|---|---|
| | **Onion skin mordant** | **Pomegranate rind mordant** |
| Pre-mordanted | 1 | 4/5 |
| Meta-mordanted | 1/2 | 4/5 |
| Post-mordanted | 1 | 4/5 |
| **Staining** on multifibre fabric (Acetate, Cotton, Nylon, Polyester, Acrylic, and Wool) was found to be **4/5** for all samples. | | |

Table 3 shows the colour fastness to washing of dyed samples. Very good colour fastness to washing is obtained with pomegranate rind mordant while onion skin mordant showed poor results. The staining on multifibre adjacent fabric is almost nil for both the mordants.

**Table 4:** Colour Fastness to Perspiration (ISO 105 E04: 2013)

| **Fabric** | **Colour Change (grade)** | | | |
|---|---|---|---|---|
| | **Onion skin mordant** | | **Pomegranate rind mordant** | |
| | **Acidic** | **Alkaline** | **Acidic** | **Alkaline** |
| Pre-mordanted | 4 | 4 | 4/5 | 4/5 |
| Meta-mordanted | 3/4 | 4/5 | 4/5 | 4/5 |
| Post-mordanted | 3/4 | 4/5 | 4/5 | 4/5 |
| Staining on multifibre fabric (Acetate, Cotton, Nylon, Polyester, Acrylic, and Wool) was found to be 4/5 for all samples. | | | | |

Table 4 shows the colour fastness to perspiration. Very good colour fastness to perspiration, both acidic and alkaline, is obtained with pomegranate rind mordant while onion skin mordant showed average results for colour fastness to acidic perspiration. The staining on multifibre adjacent fabric is almost nil in both the cases.

**Table 5:** Areal Density (GSM) (ASTM D3776: 2002)

| Fabric | Areal Density (GSM) | |
|---|---|---|
| | Onion skin mordant | Pomegranate rind mordant |
| Pre-mordanted | 53.6 | 54.2 |
| Meta-mordanted | 50.6 | 55.8 |
| Post-mordanted | 53.2 | 55.2 |
| Undyed (control) | 58.2 | |

Table 5 shows the areal density of the undyed and dyed fabric samples. It is understood that there is slight reduction in the GSM of dyed fabrics compared to the undyed fabric which may be due to the loss of fibres from the dyed fabric.

**Table 6**: Fabric Thickness (ASTM D1777: 1996)

| Fabric | Thickness (mm) | |
|---|---|---|
| | Onion skin mordant | Pomegranate rind mordant |
| Pre-mordanted | 0.22 | 0.28 |
| Meta-mordanted | 0.25 | 0.28 |
| Post-mordanted | 0.25 | 0.28 |
| Undyed (control) | 0.28 | |

Table 6 shows the thickness of the undyed and dyed fabric samples. It is understood that there is slight increase in the thickness of dyed fabrics compared to the undyed fabric. This is due to the fact that swelling of fibre occurs during wet processing of textiles and the yarns move closer to each other.

**Table 7:** Tensile Strength of Fabric (ASTM D5035: 2011)

| Fabric | Onion skin mordant | | Pomegranate rind mordant | |
|---|---|---|---|---|
| | Warp | Weft | Warp | Weft |
| Pre-mordanted | 9.3 | 12 | 8.9 | 11.6 |
| Meta-mordanted | 7.4 | 14 | 9.3 | 11.6 |
| Post-mordanted | 6.9 | 9.8 | 8.7 | 12.7 |
| Undyed (control) | Warp: 11.1, Weft: 15.18 | | | |

Table 7 shows the tensile strength of the undyed and dyed fabric samples. The onion skin mordant dyed fabric exhibits little loss in tensile strength along the warp and slightly more loss in tensile strength along the weft while the pomegranate rind mordant dyed fabric shows considerable loss in strength in both warp and weft directions.

## 4. Conclusion

Natural dye obtained from the waste banana leaves is found to be a suitable dye for cotton fabric. Among the two natural mordants used, pomegranate rind mordant shows better results and hence preferable to onion skin mordant. The dye and mordants used in the study are safe and bio-degradable and in turn eco-friendly. The ancient art of natural dyeing has to be revived by the industry to overcome the hazards caused by synthetic dyes. Natural dyes derived from agro-waste is gaining importance and could be very economical.

## 6. References


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