



## Cotton Dyeing with Natural Dye Extracted from Pomegranate (*Punica granatum*) Peel

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### Abstract:

Use of natural dyes has increased several folds in the past few years due to the eco-friendly approach of the people. This paper concerns with the purification of natural dyestuff extracted from an abundantly occurring plant '*Punica granatum*'. The main coloring agent in the pomegranate peel is granatonine which is present in the alkaloid form N-methyl granatonine. Solvent extraction method was used for the extraction of the dye. The pomegranate peel dye was used for dyeing of scoured cotton cloth using two mordants-copper sulphate and ferrous sulphate in the ratios 1:1, 1:3, 3:1. Dyeing along with mordanting techniques which included pre-mordanting, simultaneous mordanting and post mordanting was carried out. Study about fastness tests of dyed clothes was undertaken. Large range of shades was obtained because of varying mordant ratios and combinations. The production cost of the pomegranate peel dye was estimated.

**Keywords:** Color fastness, costing, granatonine, mordant, natural dye.

### Introduction:

Dyeing is an ancient art which predates written records. It was practiced since Bronze Age. The widely and commercially used synthetic dyes impart strong colors but causes carcinogenicity and inhibition of benthic photosynthesis (Adeel *et al.*, 2009). Germany was the first to take initiative to put ban on numerous specific azo-dyes for their manufacturing and applications. Netherlands, India and some other countries also followed the ban (Patel, 2011). Certain problems with the use of natural dyes in textile dyeing are color yield, complexibility of dyeing process, reproducibility results, limited shades, blending problems and inadequate fastness properties (Sachan and Kapoor, 2005; Siva, 2007). But these problems can be overcome by using chemicals called as mordants. Mordants are metal salts which produce an affinity between the fabric and the dye (Vankar *et al.*, 2009; Samanta and Agarwal, 2009).

Metal ions of mordants act as electron acceptors for electron donors to form co-ordination bonds with the dye molecule, making them insoluble in water (Mongkholrattanasit *et al.*, 2011). Alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. are the commonly used mordants. (Siva, 2007; Mahangade *etal.*, 2009; Samanta and Agarwal, 2009). Cotton textile dyeing was done since the medieval period using cheap natural dyes (Naqvi, 1980). Nature has gifted us more than 500 dye-yielding

plant species (Mahanta and Tiwari, 2005). Coloring agents of these plants are derived from roots, leaves, barks, trunks or fruits (Adeel *et al.*, 2009; Katz, 2004). All colors of rainbow are obtained from plants (Cage). Natural dyes have better biodegradability and generally have higher compatibility with the environment. They are non-toxic, non-allergic to skin, non-carcinogenic, easily available and renewable (Adeel *et al.*, 2009; Pruthi *et al.*, 2007; Saha and Dutta; Siva, 2007; Onal, 1996).

Color fastness is the resistance of a material to change any of its color characteristics or extent of transfer of its colorants to adjacent white materials in touch (Samanta and Agarwal, 2009). Generally light fastness, wash fastness and rub fastness are considered for textile fibers.

*Punica granatum* is from the family Punicaceae. It grows in all warm countries of the world and was originally a native of Persia (Goodarzian and Ekrami, 2010). The rind of pomegranate contains a considerable amount of tannin, about 19% with pelletierine (Adeel *et al.*, 2009; Tiwari *et al.*, 2010). The main coloring agent in the pomegranate peel is granatonine which is present in the alkaloid form N-methyl granatonine (Goodarzian and Ekrami, 2010). This compound gives colour to the dye. Its study will enable us to understand the structural chemistry of the coloring compound.

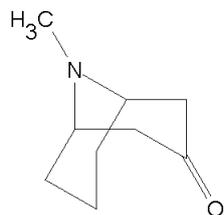


Fig 1: Structure of granatonine

## 2.0 Materials and Methods:

### 2.1 Materials:

**2.1.1 Source:** Pomegranates were purchased from Market Yard, Pune.



Fig 2: Pomegranate Peel

**2.1.2 Substrate:** 100% cotton cloth was purchased from Prakash Departmental Stores, Pune

**2.1.3 Chemicals:** Laboratory grade chemicals- 95% ethanol, copper sulphate and ferrous sulphate were supplied by Anand Agencies, Pune.

### 2.1.4 Equipments used in the Present Study:

- Weighing balance (Citizen)
- Water bath (Neolab WB344)
- Soxhlet apparatus
- Hot air oven (Thermo lab)
- Colorimeter (Erma Japan CXL)
- UV Trans illuminator (Bioera)

### 2.2 Methods:

Solvent extraction was used for extracting the dye.

**2.2.1 Preparation of Raw Material:** The samples were collected and washed thoroughly with water to remove any impurities. After drying at room temperature, the samples were ground into powder with the help of grinder (Win and Swe, 2008).

**2.2.2 Extraction of Crude Dyestuff:** 100 g of sample was weighed and taken in a round bottom flask and 500ml of solvent (ethanol water) in the ratio 40:60 was added to it. The flask was heated in a water bath at 60°C for 60mins. The solution was then filtered to obtain crude dyestuff (Win and Swe, 2008; Goodarzian and Ekrami, 2010).

**2.2.3 Purification of Crude Dyestuff:** The crude dyestuff is distilled to get 1/3rd of the solution using the Soxhlet apparatus at 70°C for 3hrs. In this process ethanol is recovered and the concentrated dye is obtained. The solution is kept overnight at room temperature for precipitation. The precipitation in ethanol water is obtained by decanting the solution. The obtained particles are dried in the oven overnight at 60°C (Win and Swe, 2008; Goodarzian and Ekrami, 2010). Water was added in the soxhlet apparatus. By addition of water, the boiling points of the compounds are lowered, allowing them to evaporate at lower temperatures (Chowdhari *et al.*, 2004).

**2.2.4 Scouring of Cotton Cloth:** Scouring of cotton cloth was done by washing it in a solution containing 0.5g/lit Sodium carbonate and 2g/lit non-ionic detergent (Tween 80) at 50°C for 25 mins, keeping the material to liquor ratio at 1:40. The scoured cotton was thoroughly washed with tap water and dried at room temperature. The scoured material was soaked in clean water for 30 mins prior to dyeing or mordanting. (Salam and Salam, 2005; Pruthi *et al.*, 2007; Jothi, 2008; Vankar *et al.*, 2009; Aminoddin and Haji, 2010).

**2.2.5 Dyeing and Mordanting:** Accurately weighed cotton cloth was treated with different metal salts (mordants used-cupric sulphate and ferrous sulphate). Three processes of mordanting were used-pre mordanting, simultaneous mordanting and post mordanting. After dyeing, the dyed material was washed with cold water and dried at room temperature (Pruthi *et al.*, 2007; Jothi, 2008; Suitcharit *et al.*, 2010).

Table 1: Conditions for Dyeing and Mordanting

Dye	Mordant	M:L	Temp.	Time
4% owf	2%owf	1:40	80°C	60mins

### 2.2.6 Fastness Tests:

The dyed material was tested for light fastness, wash fastness and rub fastness. The color fastness is usually rated either by loss of depth of color in original sample or is expressed by staining scale (Samanta and Agarwal, 2009). Light fastness was analyzed by exposing the dyed materials to direct sunlight for 24hrs. The dyed clothes were kept under UV transilluminator for 10mins. The wash fastness was carried out by washing the dyed fiber with non-ionic soap (1g/lit). The rub fastness of the dyed fiber was carried out by rubbing the fiber and checking for fading of color (Adeel *et al.*, 2009; Raja, 2010; Mishra and Patni, 2011).

### 2.2.7 Costing of the Pomegranate Peel Dye:

Cost sheet is a statement, which shows various components of total cost of a product. It classifies and analyses the components of cost of a product. To fix the selling price of a product or service, it is essential to prepare the cost sheet. It helps in fixing selling price of a product or service by providing detailed information of the cost. The costing was done taking into consideration the direct expenses, overheads and the administration charges.

### 3.0 Results and Discussion:

The yield of dye extracted from pomegranate peel was 19.2% in this process. The amount of dye extracted from rind of pomegranate was 22.5% (Goodarzian and Ekrami, 2010). Yield of the dye can be improved by using sophisticated techniques. Large number of plants gives yellow color (Cage). The fabrics dyed with pomegranate peel gave different shades of yellow, brown and black. Similarly, red and blue pigments were obtained from crude indigo extract of *Indigofera tinctoria* (Chanayath *et al.*). Mordants play very important role in imparting color to the fabric. The mordants used in combination in different ratios gave varying shades. Better color strength results are dependent on the metal salt used (Kamel *et al.*, 2009). Strong co-ordination tendency of Fe enhances the interaction between the fiber and the dye, resulting in high dye uptake (Jothi, 2008). Ferrous sulphate and Copper sulphate have the ability of forming co-ordination complexes (Co-ordination numbers are 6 and 4 respectively). Functional groups such as amino and carboxylic acid on the fiber can occupy the unoccupied sites on interaction with the fiber. Thus, a ternary complex is formed by the metal salt on which one site is with the fiber and the other site is with the dye.



Fig. 3: Application of Dye on Cotton Cloth

The mordanted cotton cloth was immediately used for dyeing because some mordants are light sensitive. The chromophore of the dye makes it resistant to photochemical attack, but the auxochrome may alter the fastness (Jothi, 2008). Good light fastness was observed in fabrics dyed with the dye extracted from pomegranate peel. This is due to the formation of complex with the metal which protects the chromophore from photolytic degradation. Wash fastness of the dye is influenced by the rate of diffusion of the dye and state of the dye inside the fiber (Jothi, 2008). The fiber dyed with pomegranate peel dye showed moderate wash fastness. Good rub fastness was exhibited by the fibers dyed using the dye extracted from the pomegranate peel. Complexing the fiber with mordant, has the effect of insolubilizing the dye, making it color fast. The fabrics dyed with pomegranate rind exhibit good fastness properties (Adeel *et al.*, 2009).

Mordants give different shades to the fabric. Similarly, wide range of soft and light colors was obtained on silk using the dye extracted from flower of *Spathadia campanulata* (Kumaresan *et al.* 2011). The natural dye extracted from pomegranate peel might be used as a possible substitute for the synthetic dyes having banned aryl-amine moieties (Adeel *et al.*, 2009). Costing was done. The production cost was estimated to be Rs.16,386 per kilogram of the pomegranate peel dye. This included the cost of raw materials and chemicals used, electricity consumption, packing, transportation, labour and administration charges. However, capital investment of the laboratory equipments and glassware has to be done.

#### Cost Sheet for 1 Kg of Pomegranate Peel Dye

Sr. No.	Particulars	Rupees	Rupees
1)	<b>Direct Material</b>		
	a) Peel of Pomegranate (33kg)	2,475/-	
	b) Ethanol (40 L)	7,600/-	
	c) Water (60 L)	1,500/-	
	<b>Total</b>		<b>11,575</b>
2)	<b>Direct Labor (Rs. 500 for 3 days)</b>	<b>1,500/-</b>	
	<b>Direct Expenses</b>		
3)	Oven Distillation Unit, Water Bath and Heating Mantle	<b>1,445/-</b>	
	<b>Prime Cost</b>		<b>14,520/-</b>
4)	Add: Overheads		
	Administrative Expenses* (Travelling and Stationery)	240/-	
	Packaging Material	120/-	<b>360/-</b>
	<b>Total Cost</b>		<b>14,880/-</b>
5)	<b>Profit Margin 10 %</b>		<b>1,488/-</b>
	<b>Selling Price</b>		<b>16,368/-</b>

#### 4.0 Conclusion:

The whole process of extraction and dyeing is ecologically safe. The obtained results have shown the dyeing potential of pomegranate peel as source for cotton dyeing. Good fastness exhibited by the dyed clothes is because of the mordants used. There is need for proper knowledge, documentation and assessment of dye- yielding plants as well as the dyeing techniques so as to increase the use of natural dyes. There is a lot of scope to use the pomegranate peel dye for obtaining various color shades using safe mordants under eco-friendly textile dyeing. The

process of production of pomegranate peel dye was found to be cost-effective as compared to the cost of dyes in local market.

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